



Steam Generator Tube Rupture

Chapter 4.6

Objectives

1. Discuss why operator intervention is necessary to limit or prevent radiological releases during a Steam Generator Tube Rupture (**SGTR**) event.
2. Discuss the primary-side and secondary-side indications of an SGTR in the control room.
3. Discuss how the affected SG may be identified either prior to or following the reactor/turbine trip.

Objectives (Cont)

4. List the initial actions taken by the operator once the affected SG has been identified.
5. Discuss the actions required to stop the primary-secondary leakage.
6. Discuss the problems associated with the following: Secondary-to-primary leakage, SG Overfill.
7. List the principal systems/components affected by a **loss of offsite power** (LOOP).

Objectives (Cont)

8. Discuss how plant cooldown and pressure control are accomplished with an SGTR and LOOP.
9. Discuss what affect the following events had on the SGTR transient at the Ginna Plant:
 - Tripping of the reactor Coolant Pumps,
 - Failure of pressurizer power-Operated relief valve,
 - Automatic operation of letdown valves,
 - Pressurizer relief tank failure, and
 - Steam generator Safety Valve Failure.

SGTR

- Most frequent occurring major accident.
- Provides a direct release path for primary coolant to environment via SG and its safety/relief valves (Containment Bypass).
- Timely operator involvement is required to prevent SG overfill and limit radiological releases.



Figure 4.6-1 Closeup View of SGTR

Past Steam Generator Tube Rupture Accidents at Pressurized Water Reactors

Plant	Date	Leak Rate (gpm)	Cause
Point Beach Unit 1	February 26, 1975	125	wastage
Surry Unit 2	September 15, 1976	330	PWSCC in U-bend
Doel Unit 2	June 25, 1979	135	PWSCC in U-bend
Prairie Island 1	October 2, 1979	390	loose parts
Ginna Unit 1	January 25, 1982	760	loose parts and tube wear
Fort Calhoun	May 16, 1984	112	ODSCC at a crevice
North Anna Unit 1	July 15, 1987	637	high cycle fatigue in a U-bend
McGuire Unit 1	March 7, 1989	500	ODSCC in the free span
Mihama Unit 2	February 9, 1991	700	high cycle fatigue
Palo Verde Unit 2	March 14, 1993	240	ODSCC
Indian Point Unit 2	February 15, 2000	150	PWSCC in U-bend

Industry Improvements

- Secondary Side Inspections
- Improved Steam Generator Designs
- Water Chemistry Control
- More Reliable Eddy Current Techniques

Primary-Side Indications of SGTR

- Decreasing Prz level
- Decreasing Prz Pressure.
- Increasing charging flow.

These indication would also occur for a LOCA, how could the operator differentiate between the two?

- Lack of degraded containment conditions.
- Abnormal secondary side indications.

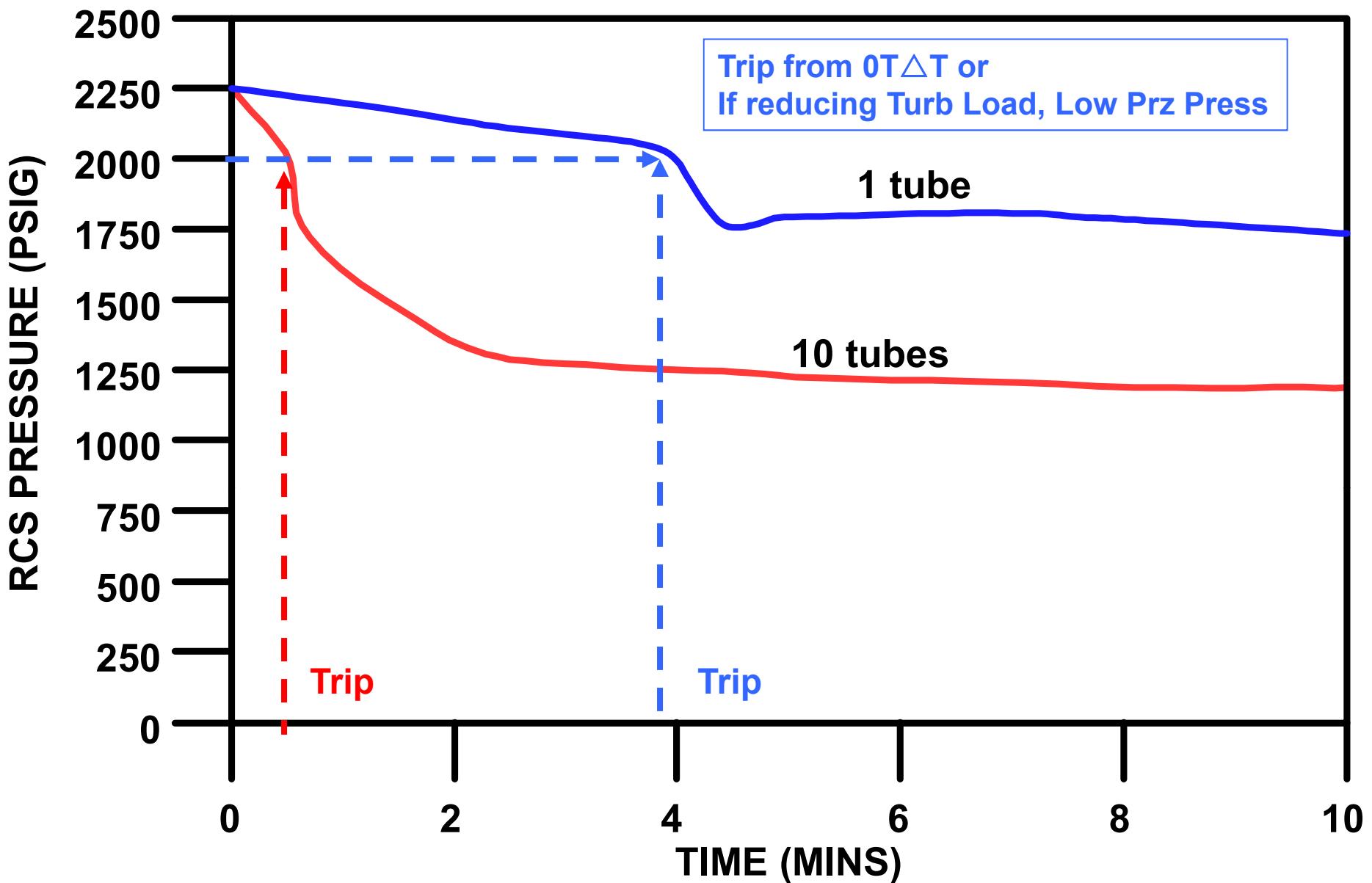


Figure 4.6-2(a) Initial Pressurizer Pressure Response
4.6-35

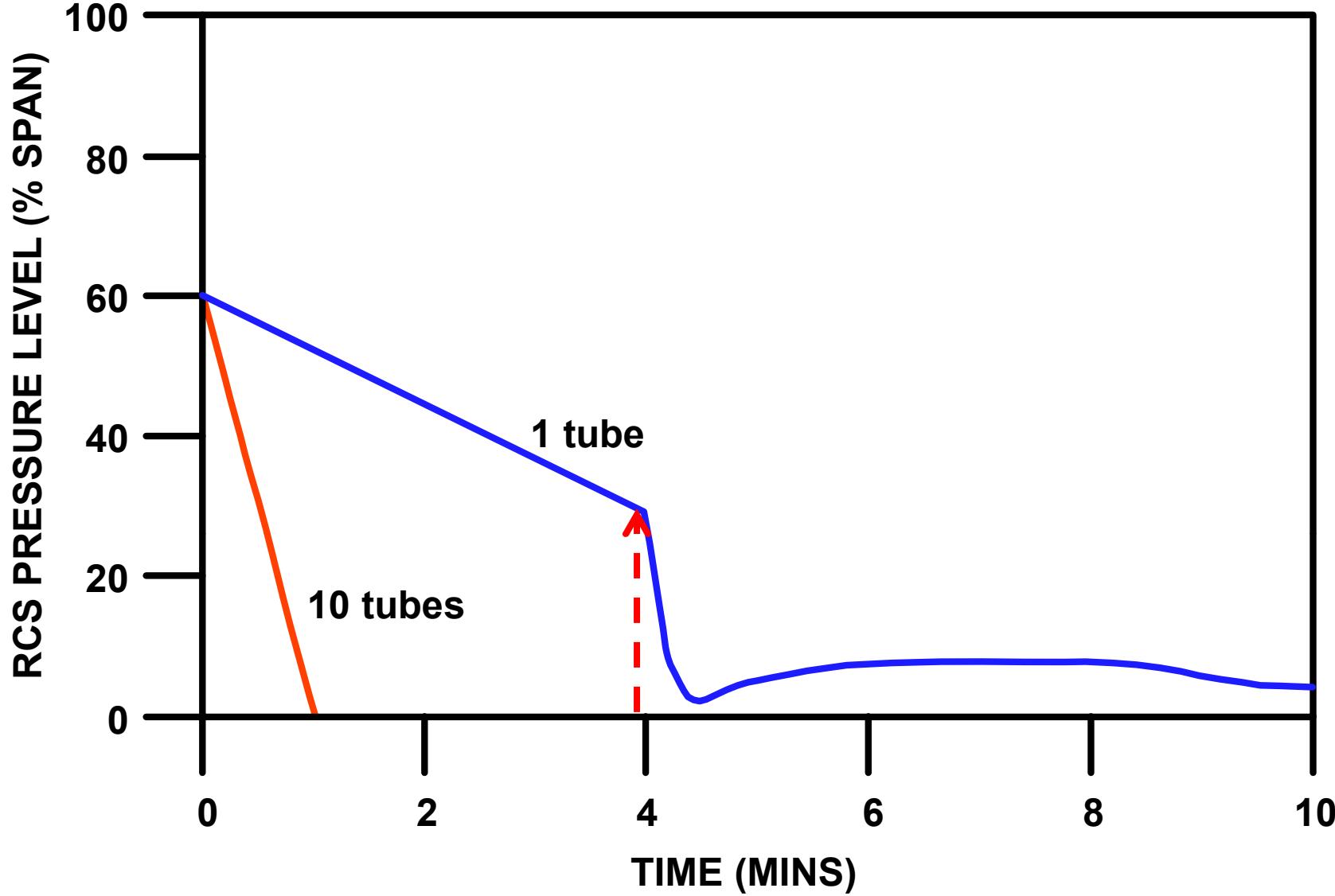


Figure 4.6-2(b) Initial Pressurizer Level Response
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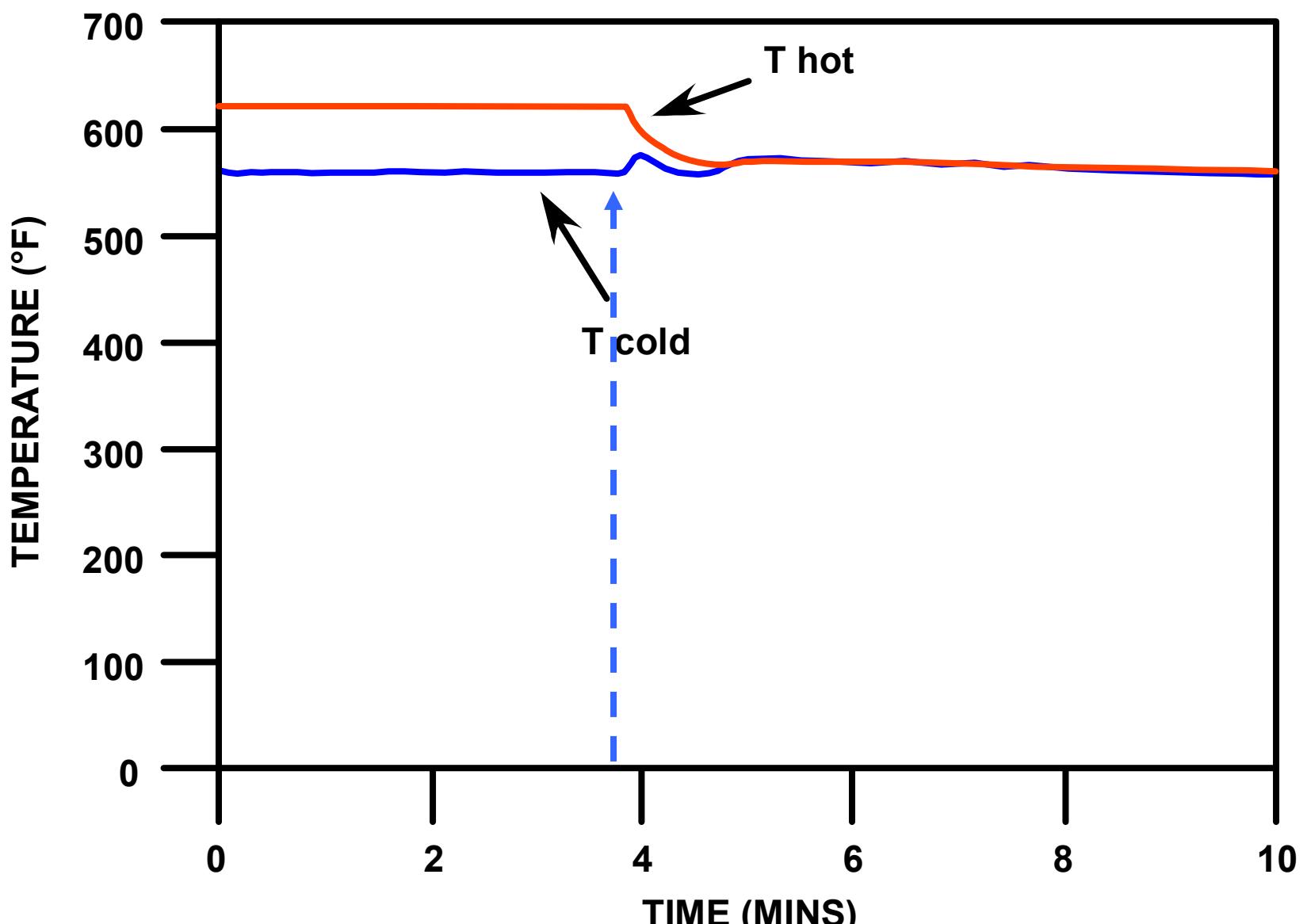


Figure 4.6-3 RCS Temperature Following Reactor Trip
4.6-37

Secondary-Side Indications of SGTR

- Chemistry Samples.
- Condenser Off Gas RM.
- SGBD Rad Monitor Alarms.
- Main Steam Line RM's
- SF/FF mismatch on affected SG.
- SG level rise on affected SG.

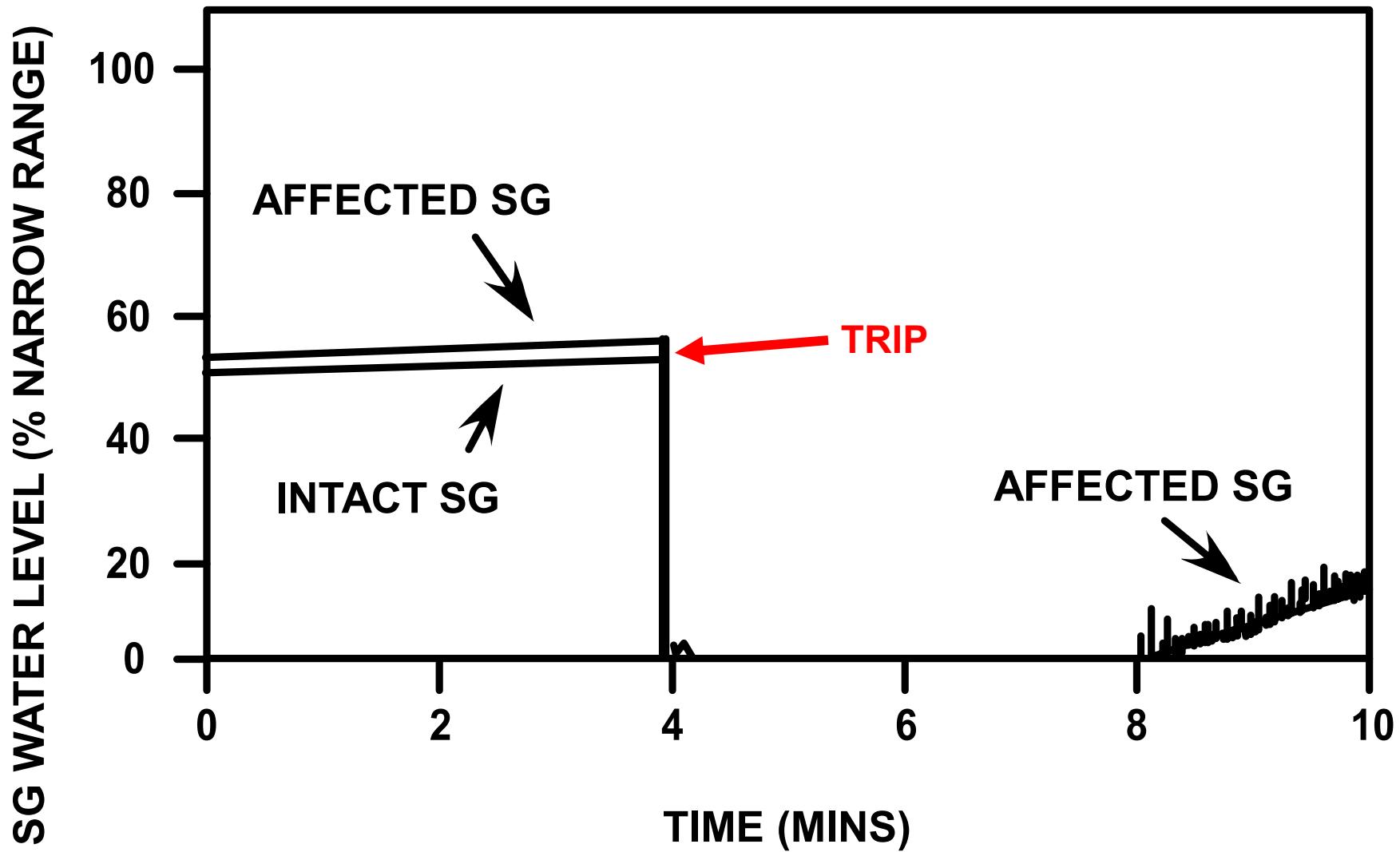


Figure 4.6-4(a) Steam Generator Response Following Reactor Trip
4.6-39

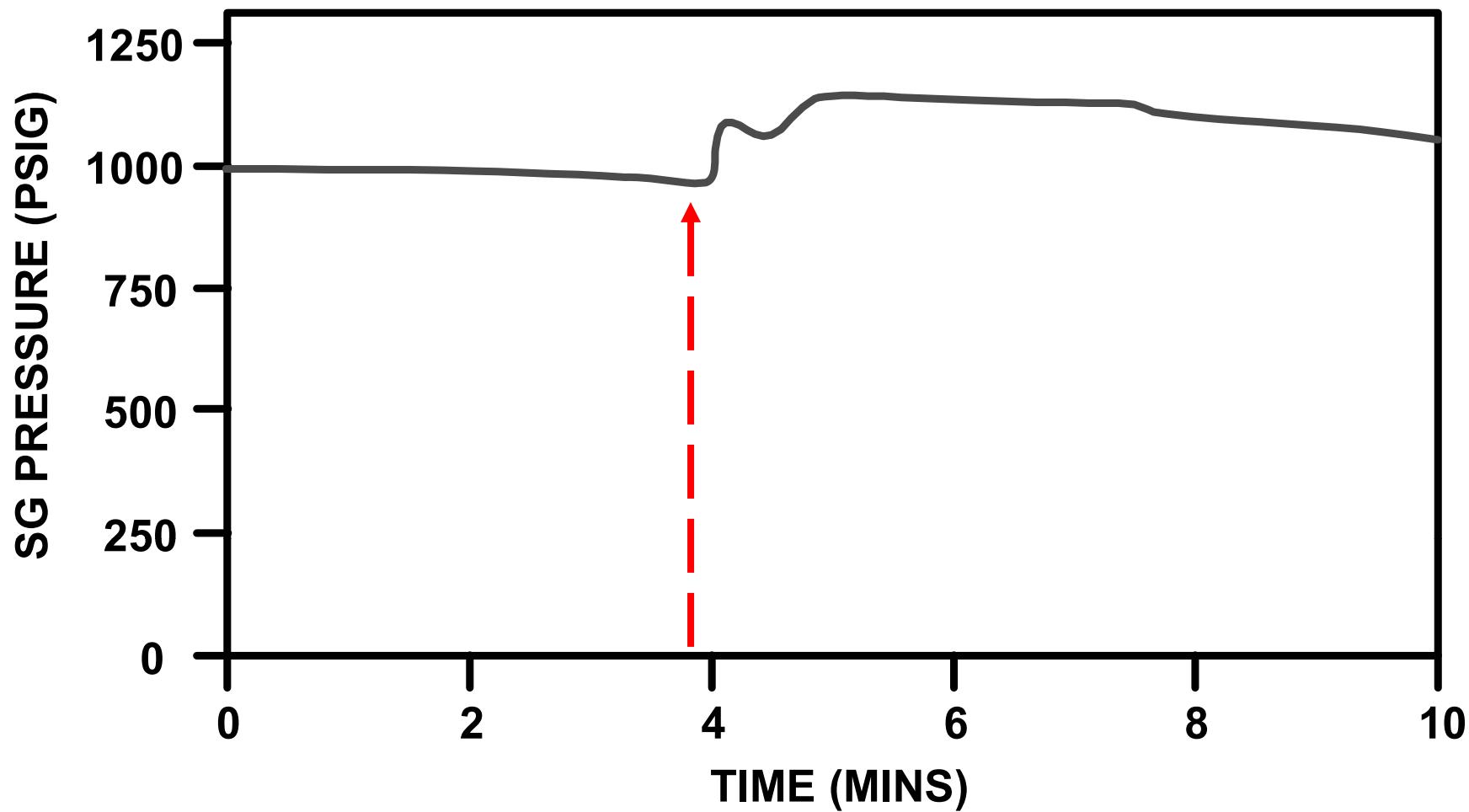


Figure 4.6-4(b) Steam Generator Response Following Reactor Trip
4.6-39

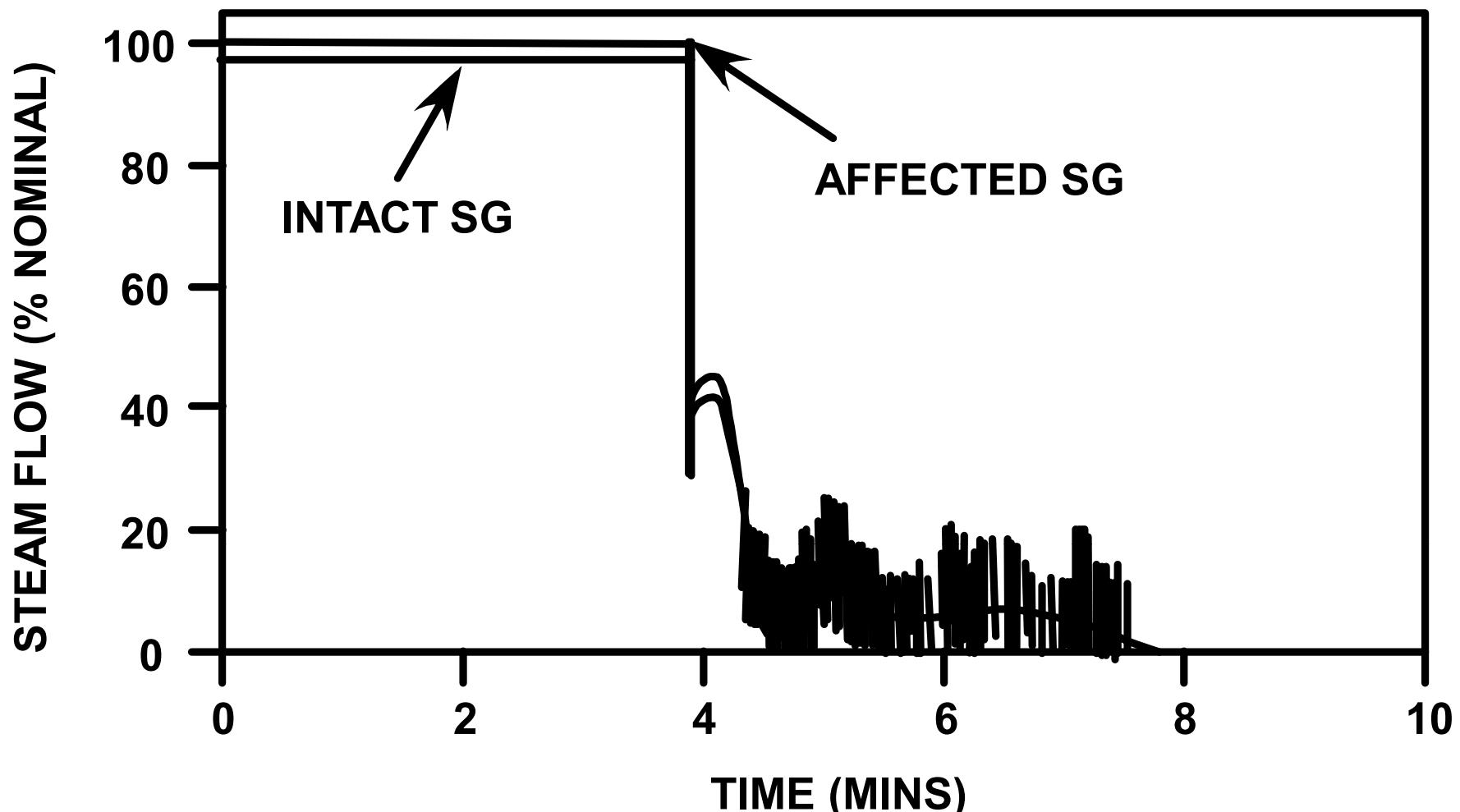


Figure 4.6-4(c) Steam Generator Response Following Reactor Trip
4.6-39

Initial Operator Actions

- Isolate the affected SG.
 1. Isolate Feedwater & AFW.
 2. Close MSIV.
- These actions help minimize radiological releases & prevent SG overfill.
- Isolating the affected SG also allows use of the non-affected SG for cooling down RCS.

Recovery Actions

- Following isolation of the effected SG the intent is to match RCS pressure with affected SG pressure to stop the leak.
- 1st step **cooldown** RCS using intact SG's.
- 2nd step **depressurize** RCS using Prz sprays or PORV if RCPs unavailable.
- 3rd Step **terminate SI** to prevent re-pressurization of RCS.

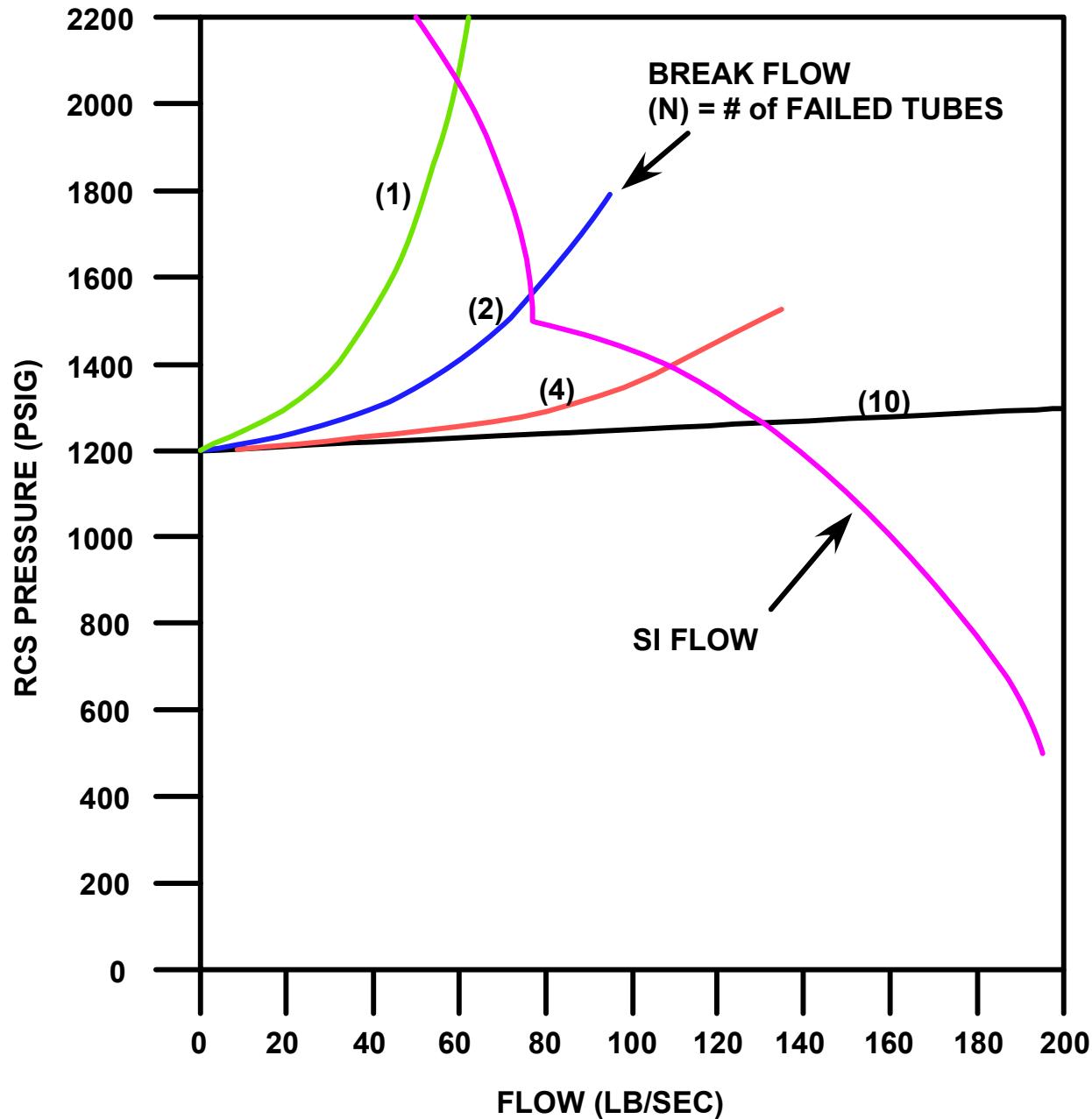


Figure 4.6-5 Equilibrium Break Flow
4.6-41

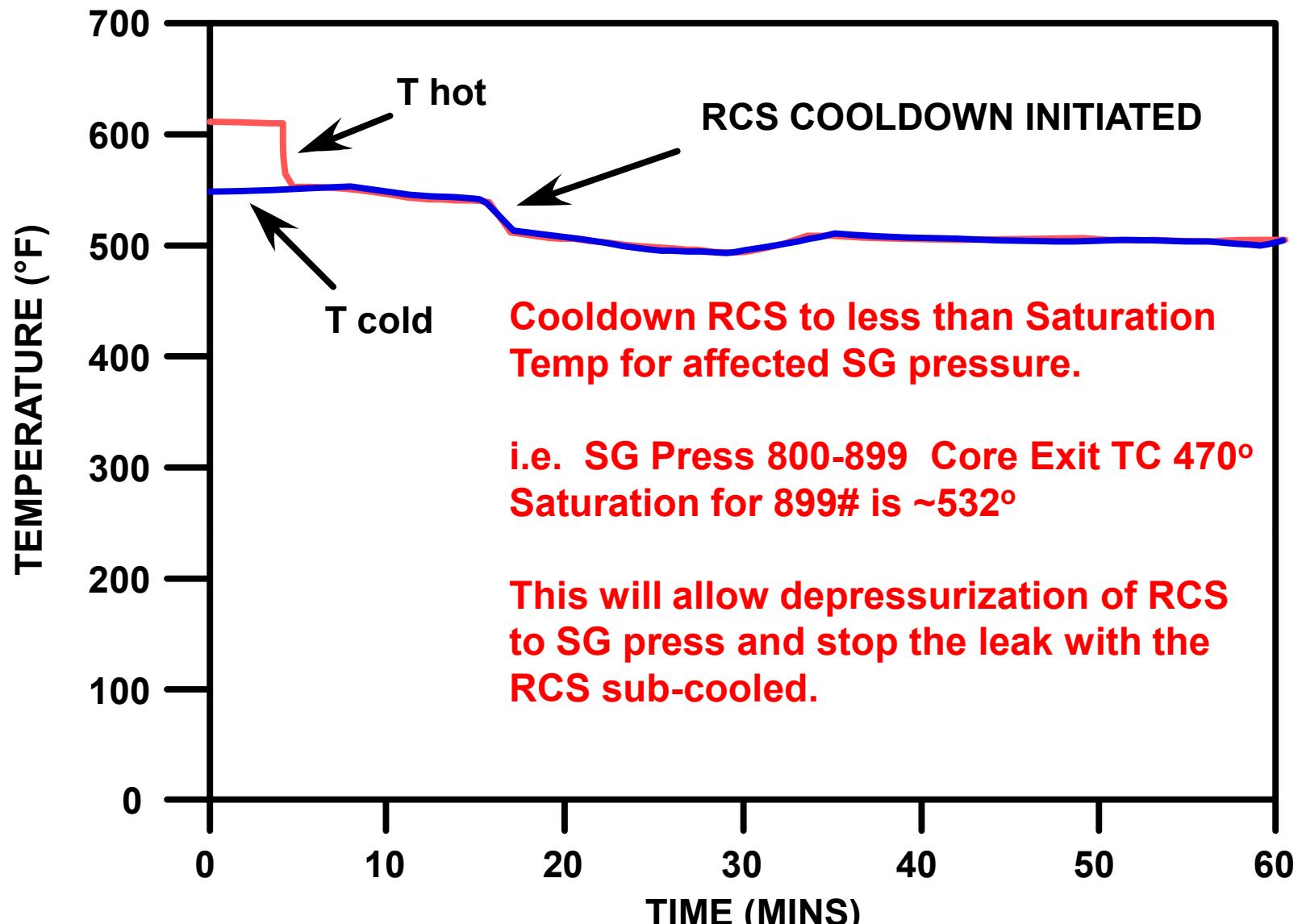


Figure 4.6-6 RCS Response - Offsite Power Available
4.6-43

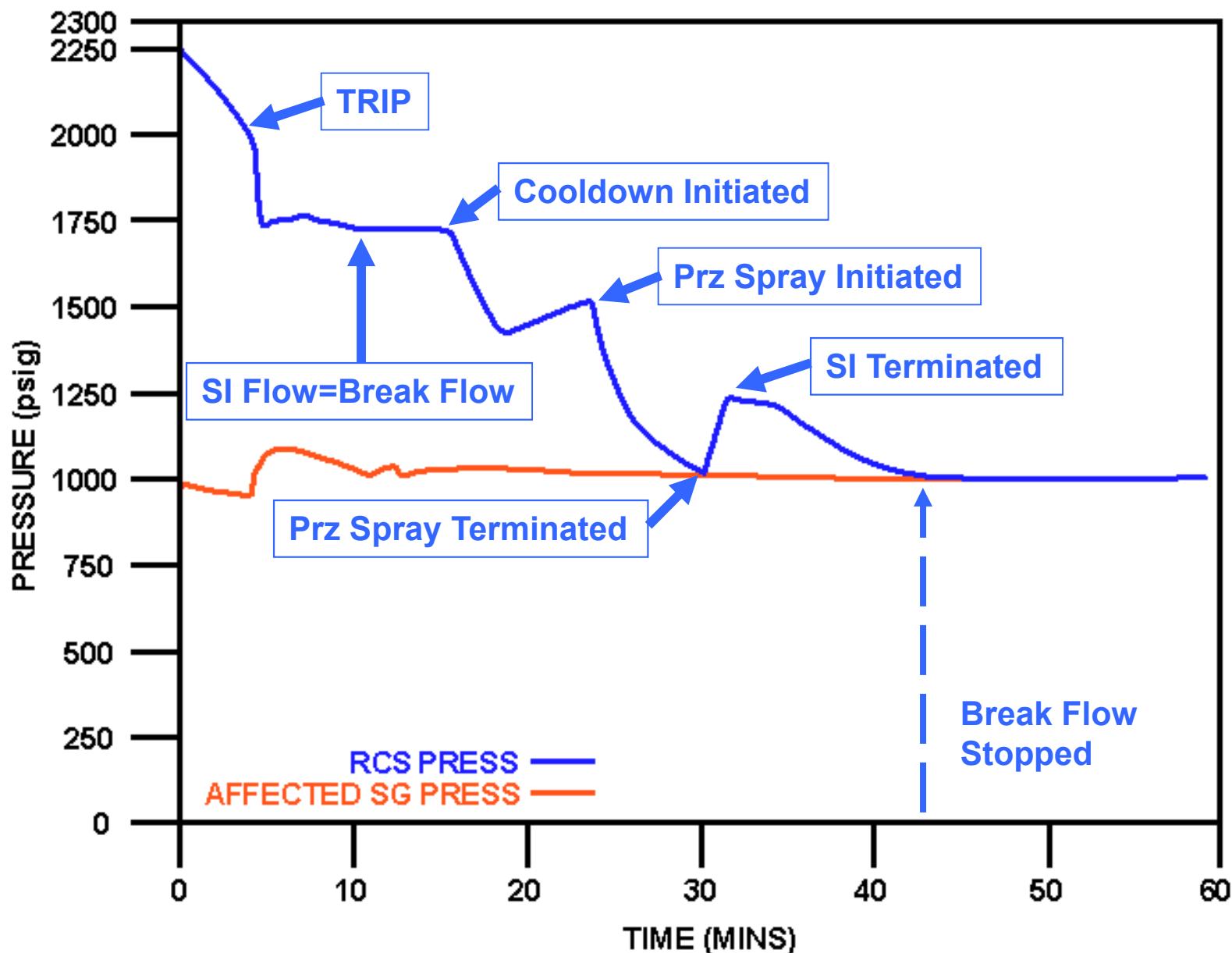


Figure 4.6-11 RCS and Ruptured SG Pressure Following SI Termination
4.6-53

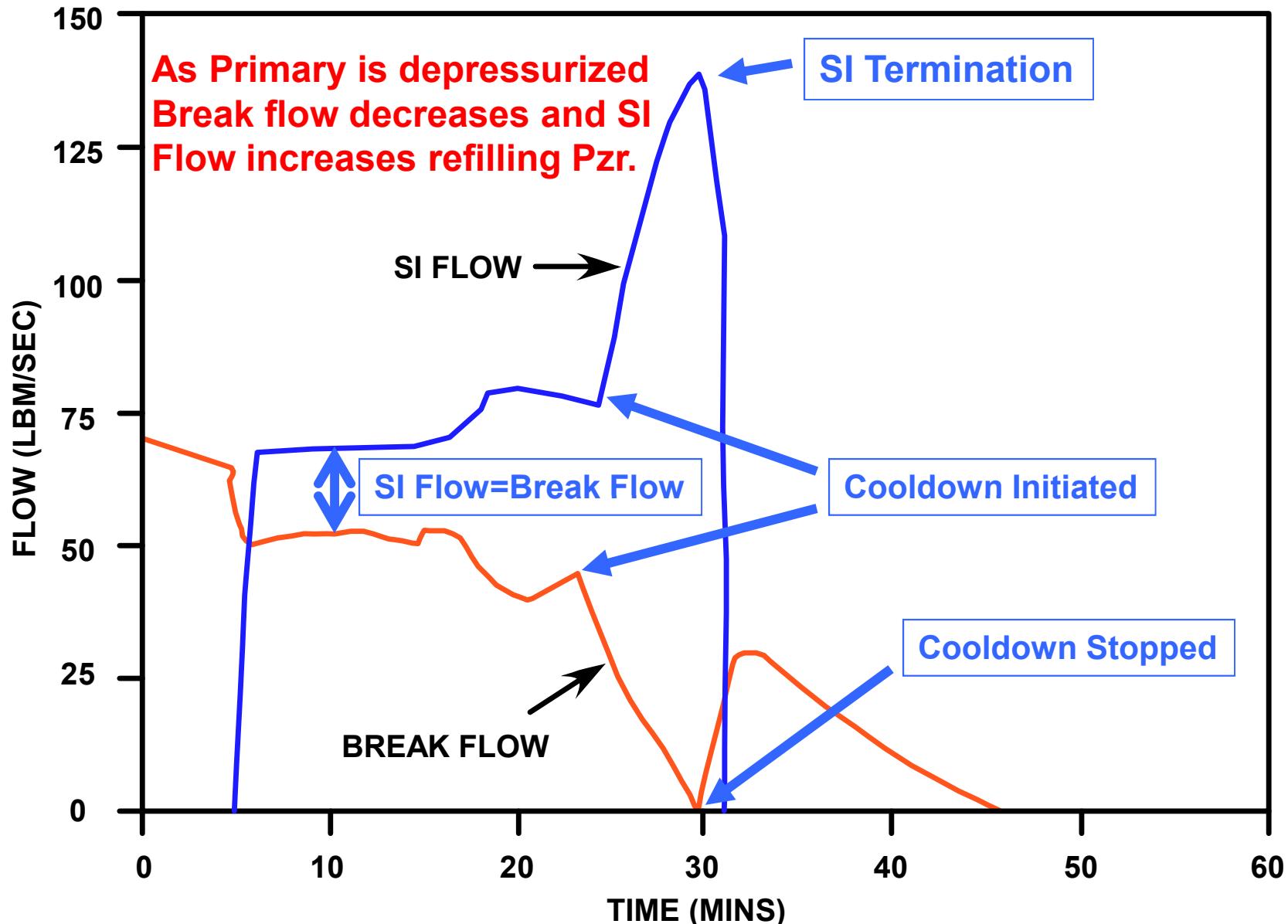


Figure 4.6-8 SI Flow and Break Flow
4.6-47

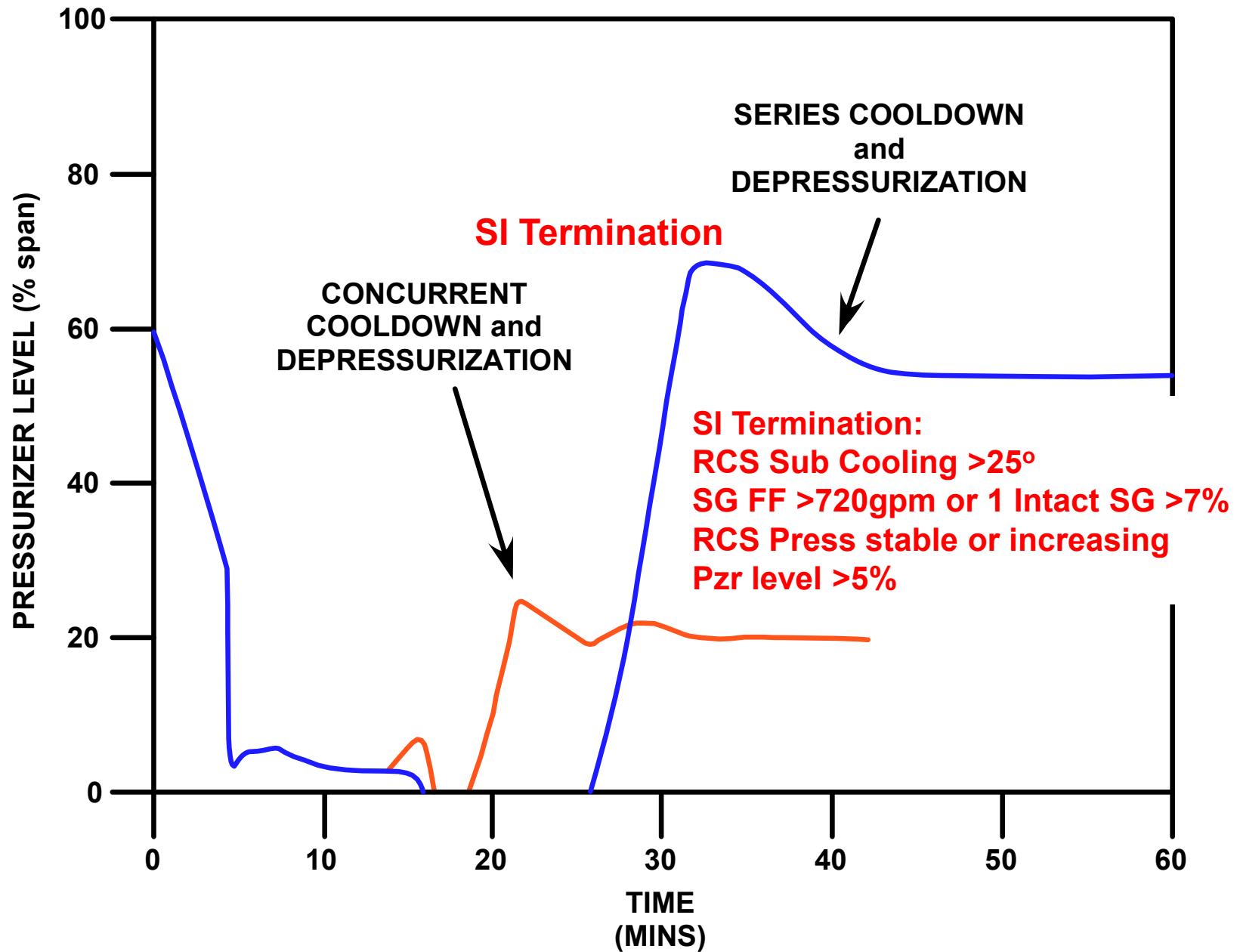


Figure 4.6-10 Pressurizer Level Response - RCS Cooldown and Depressurization

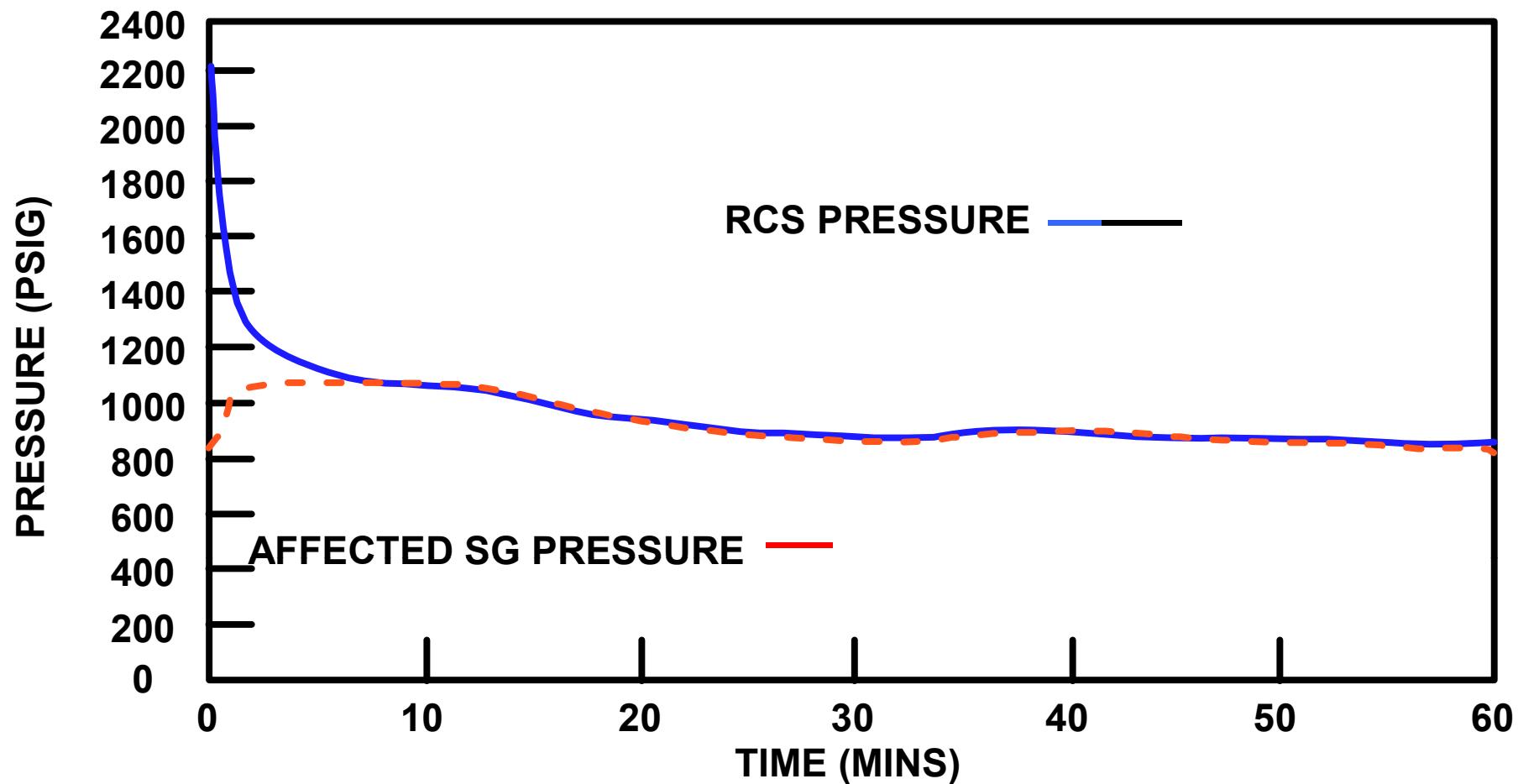


Figure 4.6-7(a) **Multiple Tube Failure Response**
4.6-45

When several tubes fail RCS pressure can drop below SG pressure during recovery. This can result in secondary – to – primary leakage which will dilute RCS boron concentration thus effecting SDM.

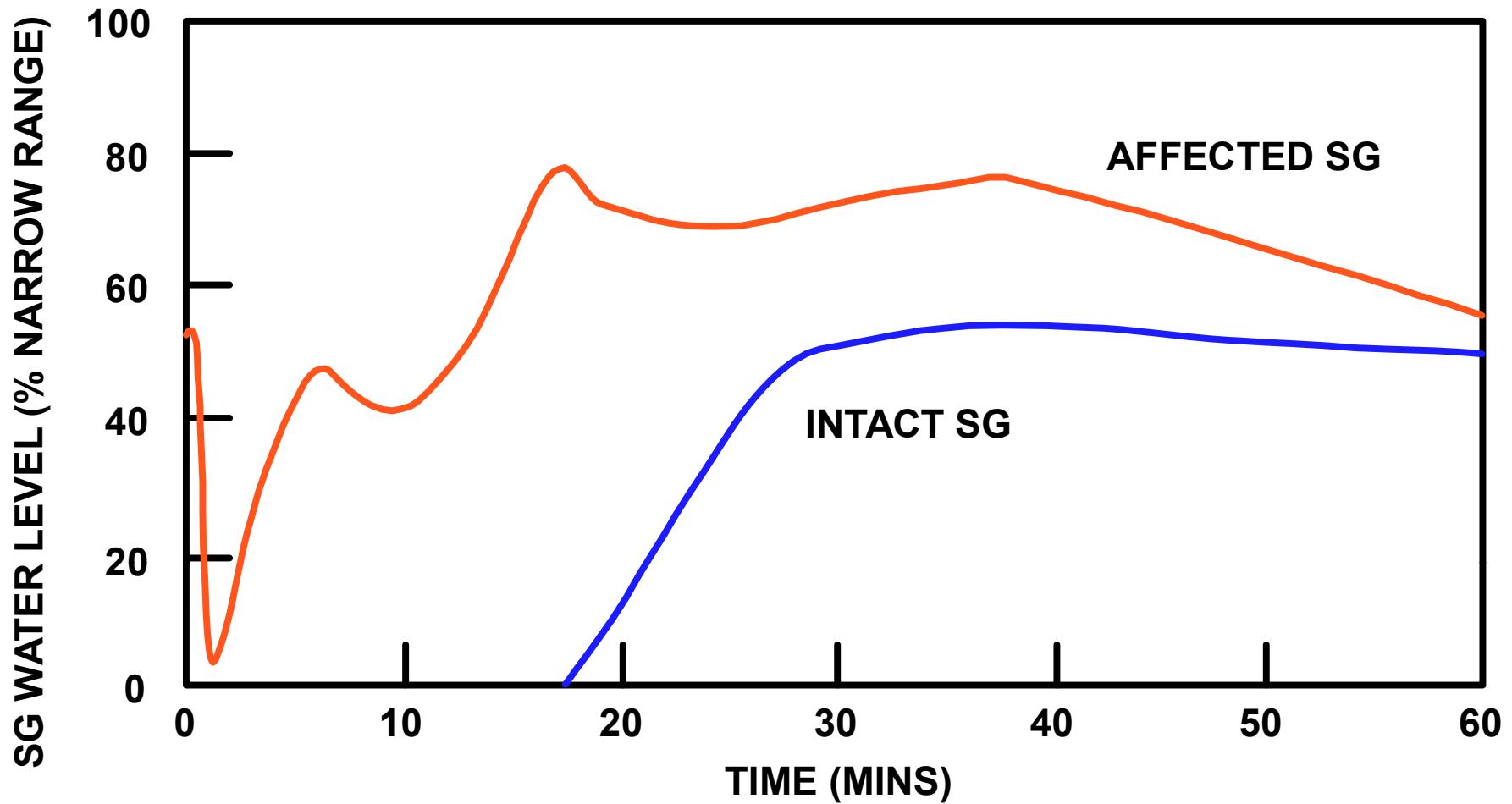


Figure 4.6-79(b) **Multiple Tube Failure Response**
4.6-45

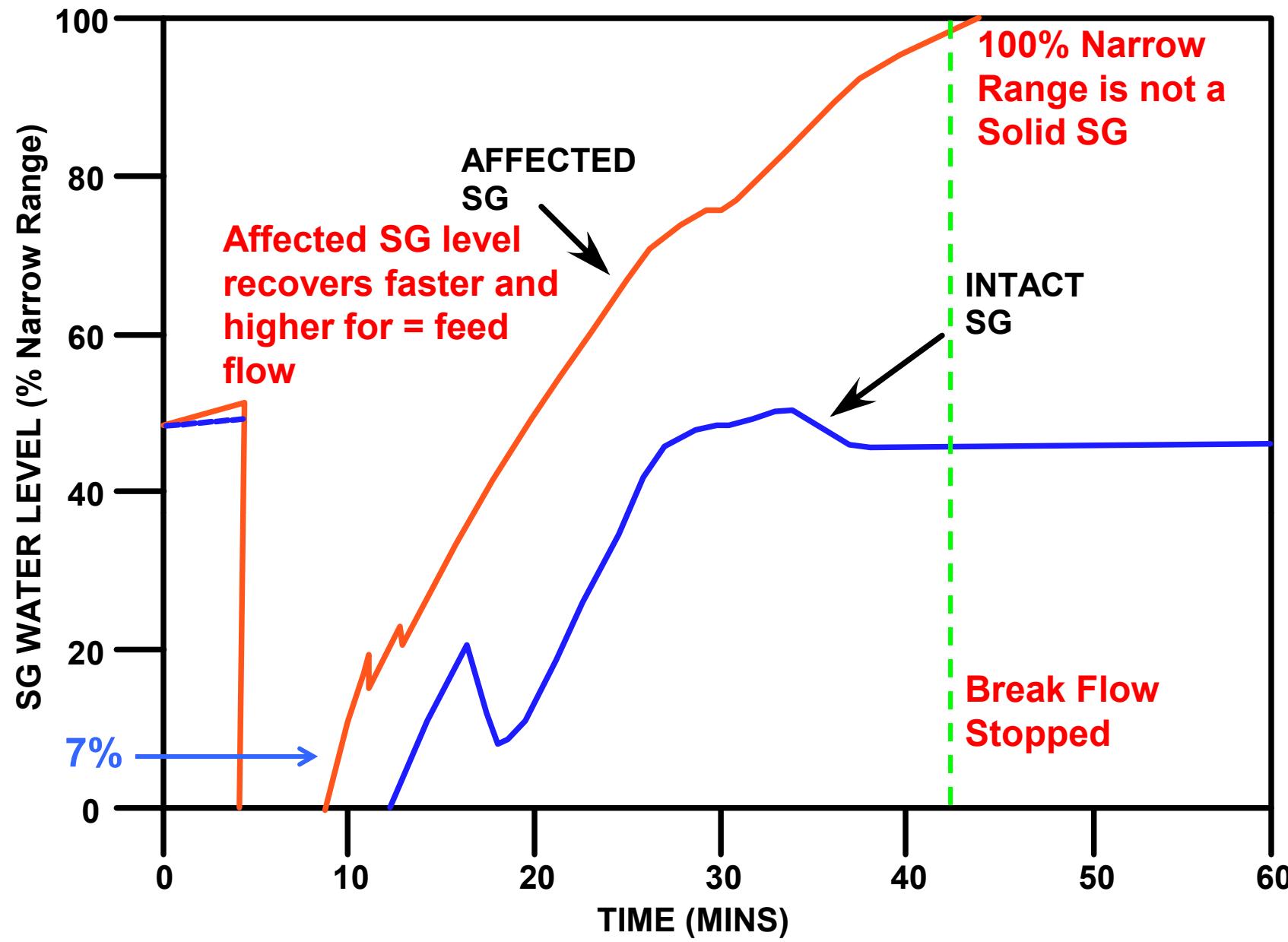


Figure 4.6-12 Steam Generator Levels
4.6-55

SGTR with LOOP

- No RCPs – natural circulation cooldown required, slows recovery.
- No Steam Dumps to condenser – must use SG PORVs.
- Prz Sprays unavailable – must use Prz PORVs or Aux Spray.
- Overall this results in increased potential for rad releases and SG overfill

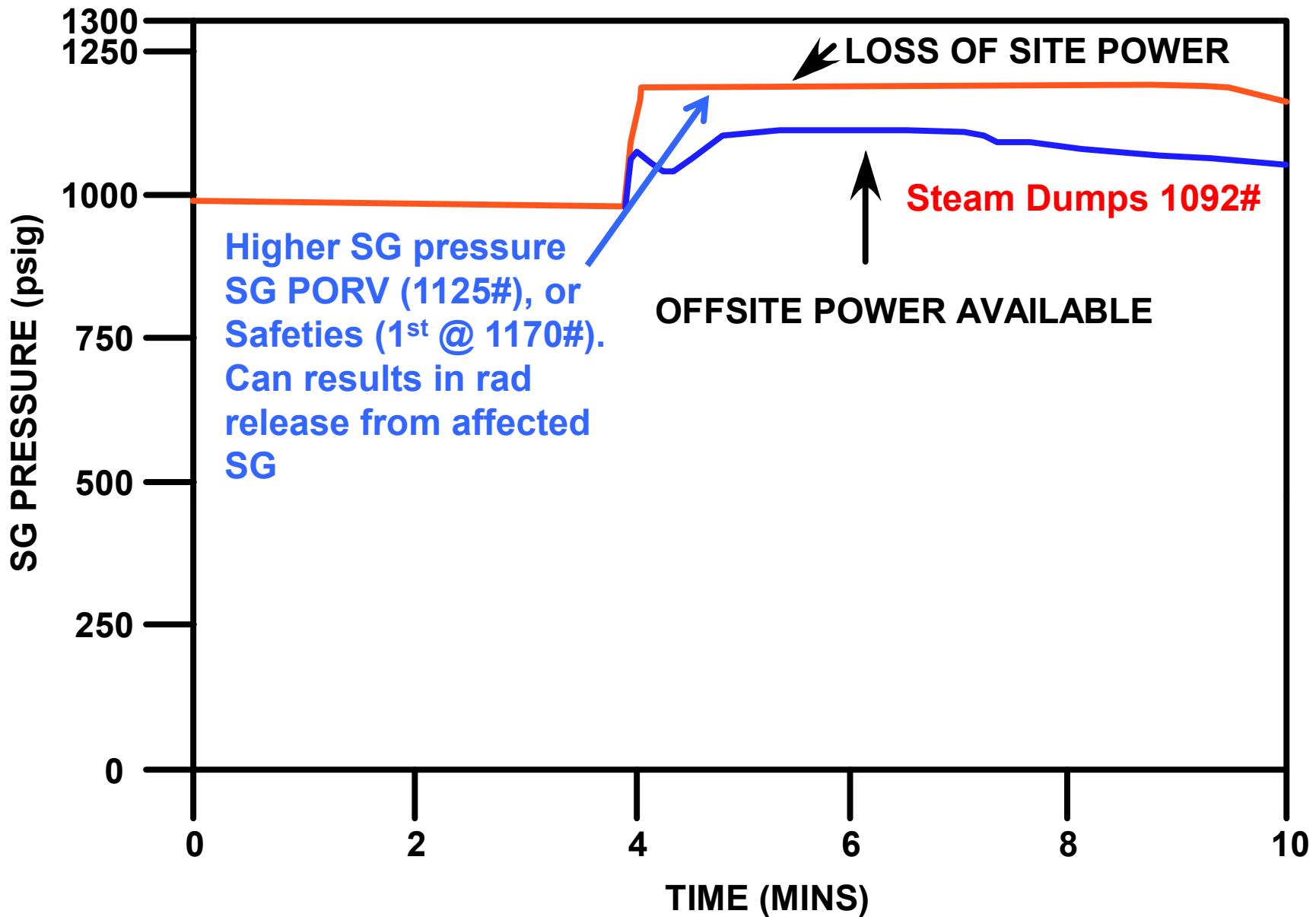


Figure 4.6-13 Steam Generator Pressure Following Reactor Trip
With and Without Offsite Power

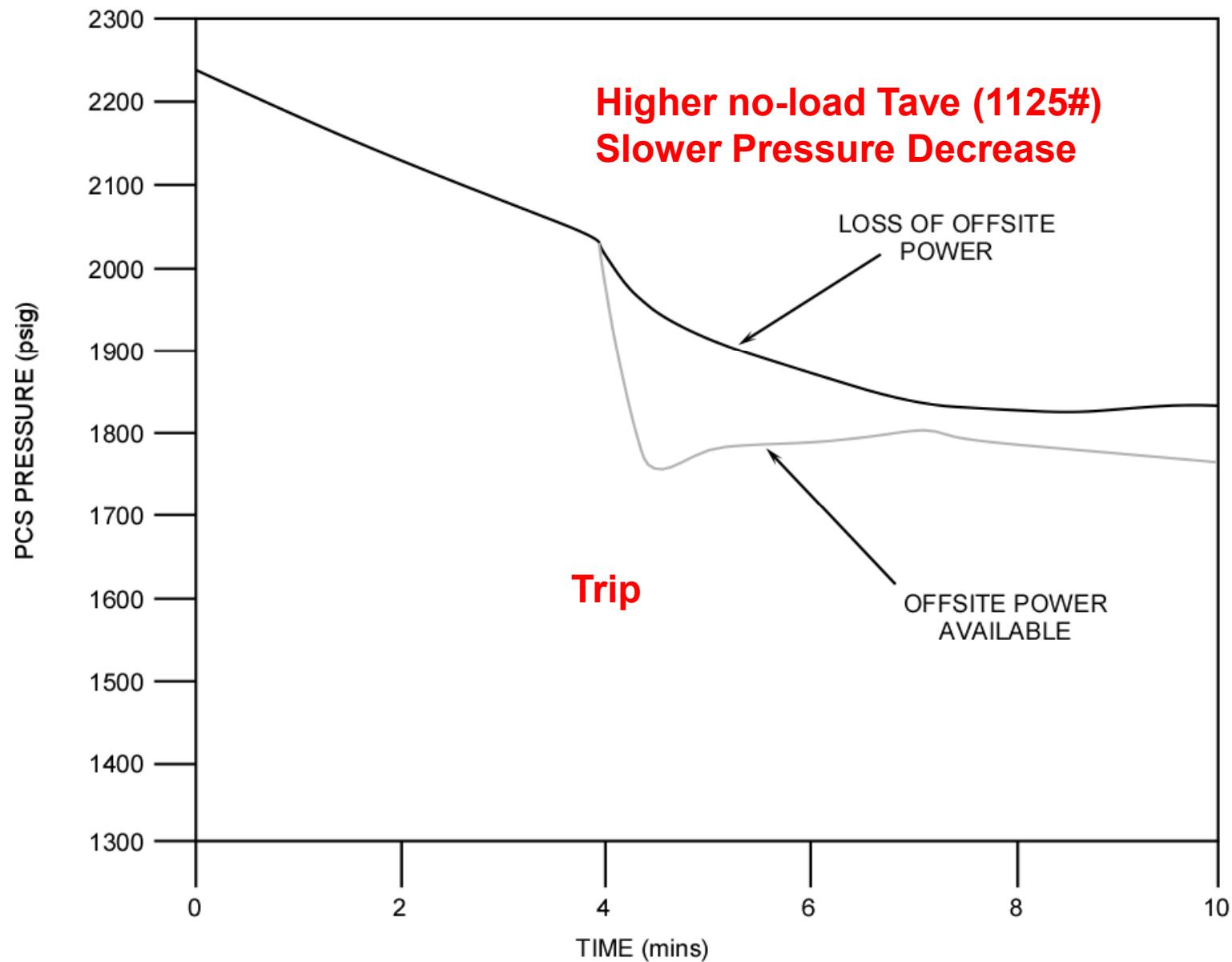


Figure 4.6-14 RCS Pressure Following Reactor Trip
With and Without Offsite Power

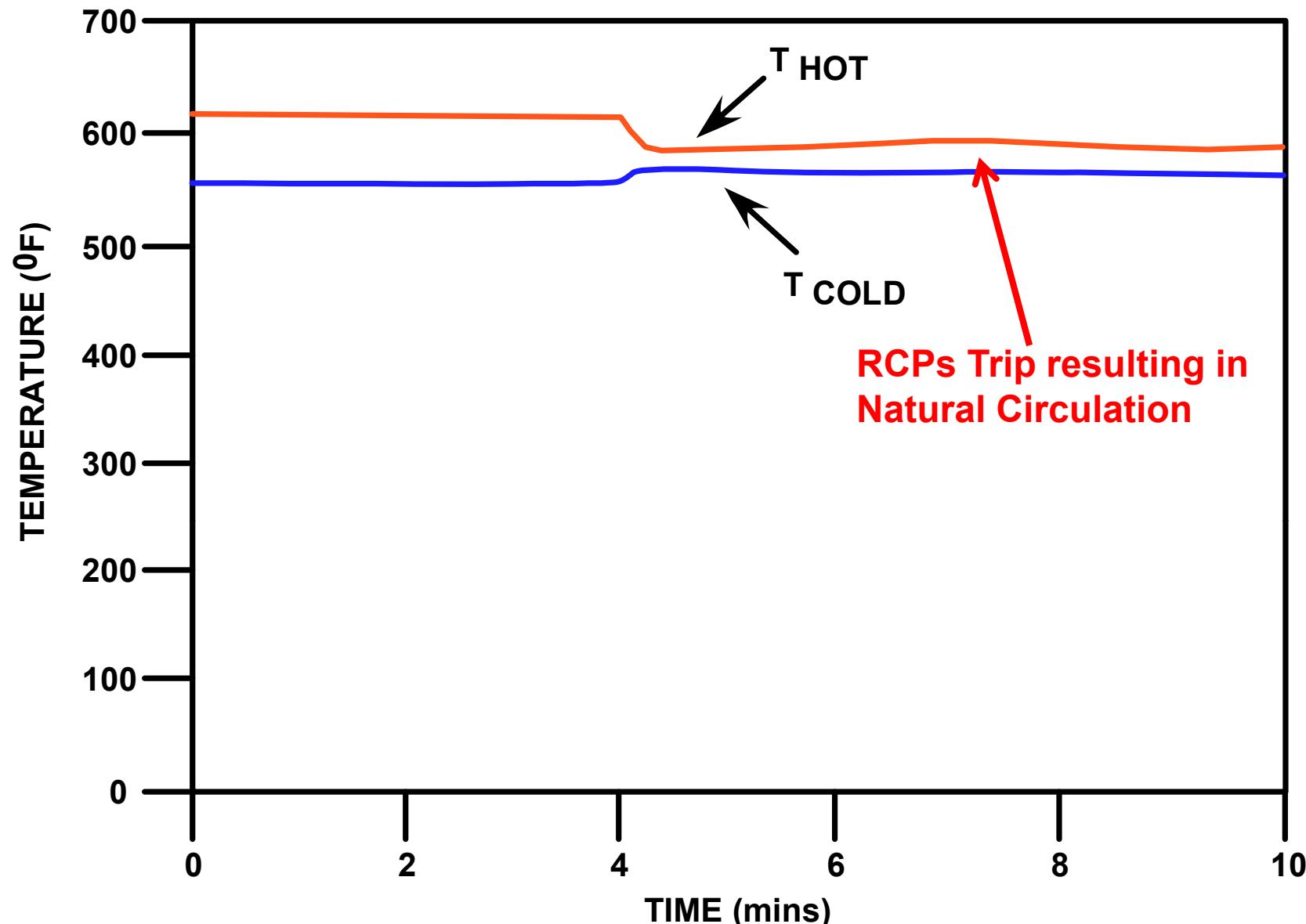


Figure 4.6-15 RCS Temperature Following Reactor Trip Without Offsite Power
4.6-61

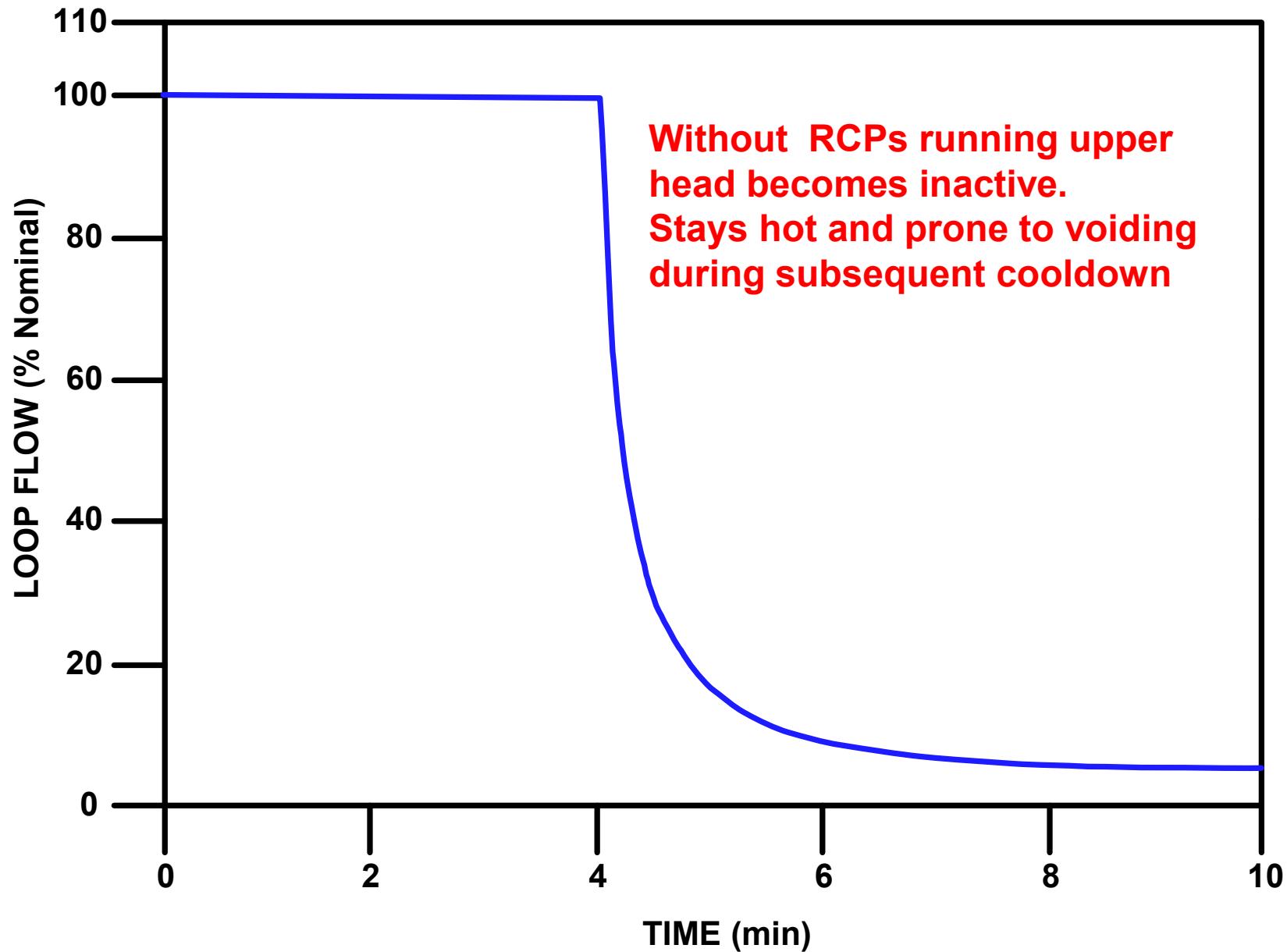


Figure 4.6-16 Natural Circulation Flow Following Loss of Offsite Power
4.6-63

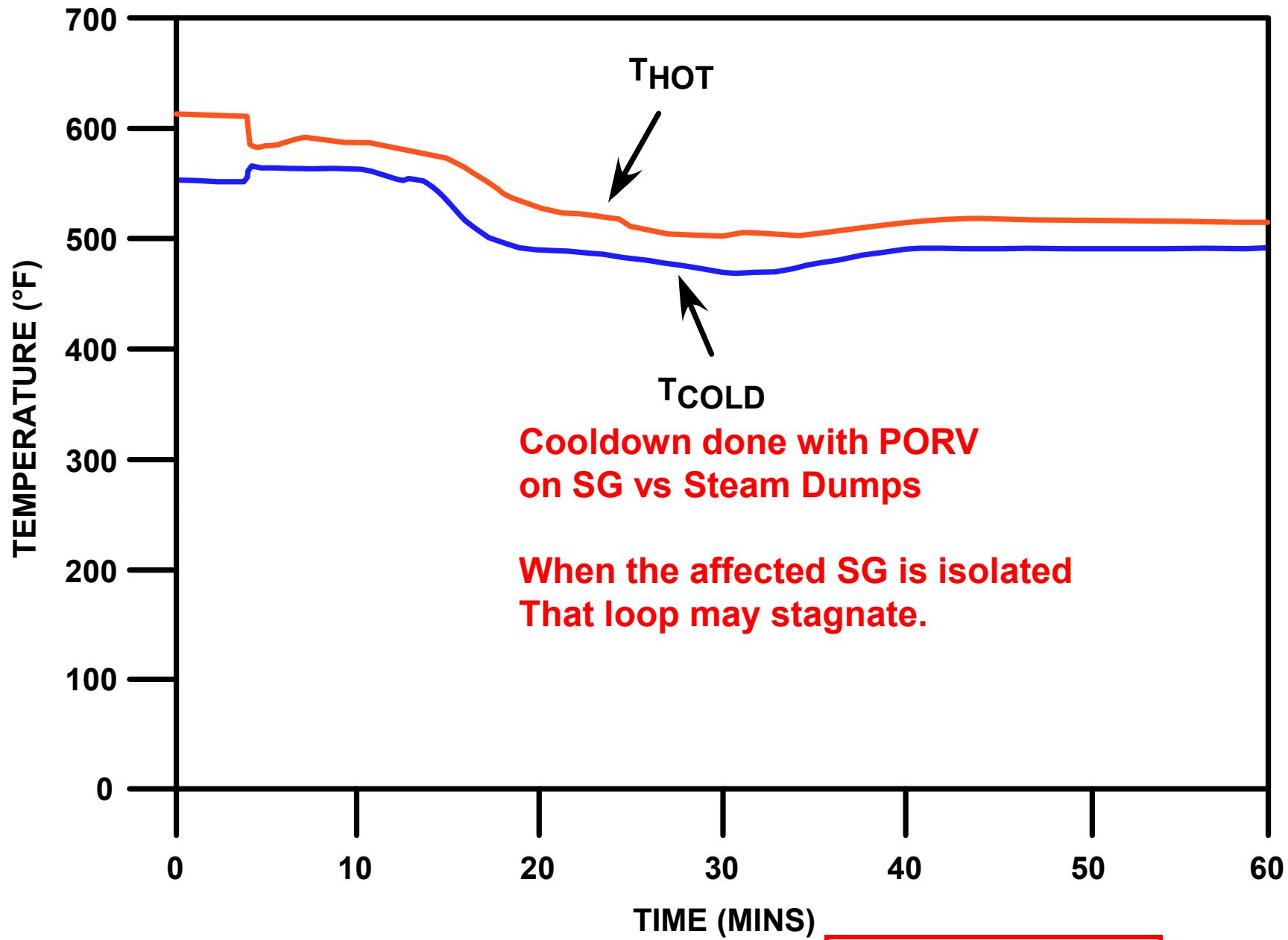


Figure 4.6-17 Intact RCS Temperature, Without Offsite Power
4.6-65

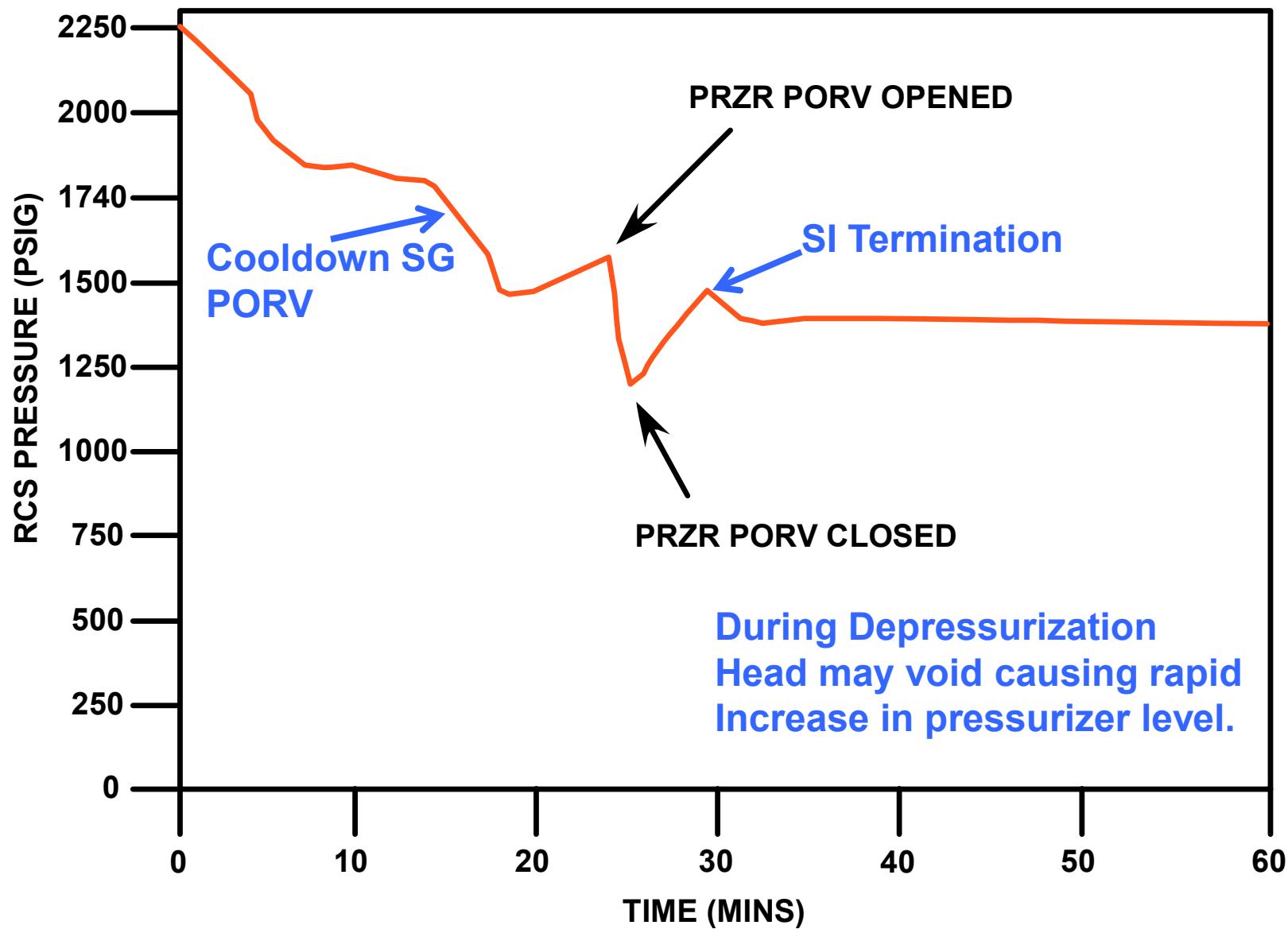


Figure 4.6-18 RCS Pressure Response, Without Offsite Power
4.6-67

Questions



Ginna SGTR
January 25, 1982

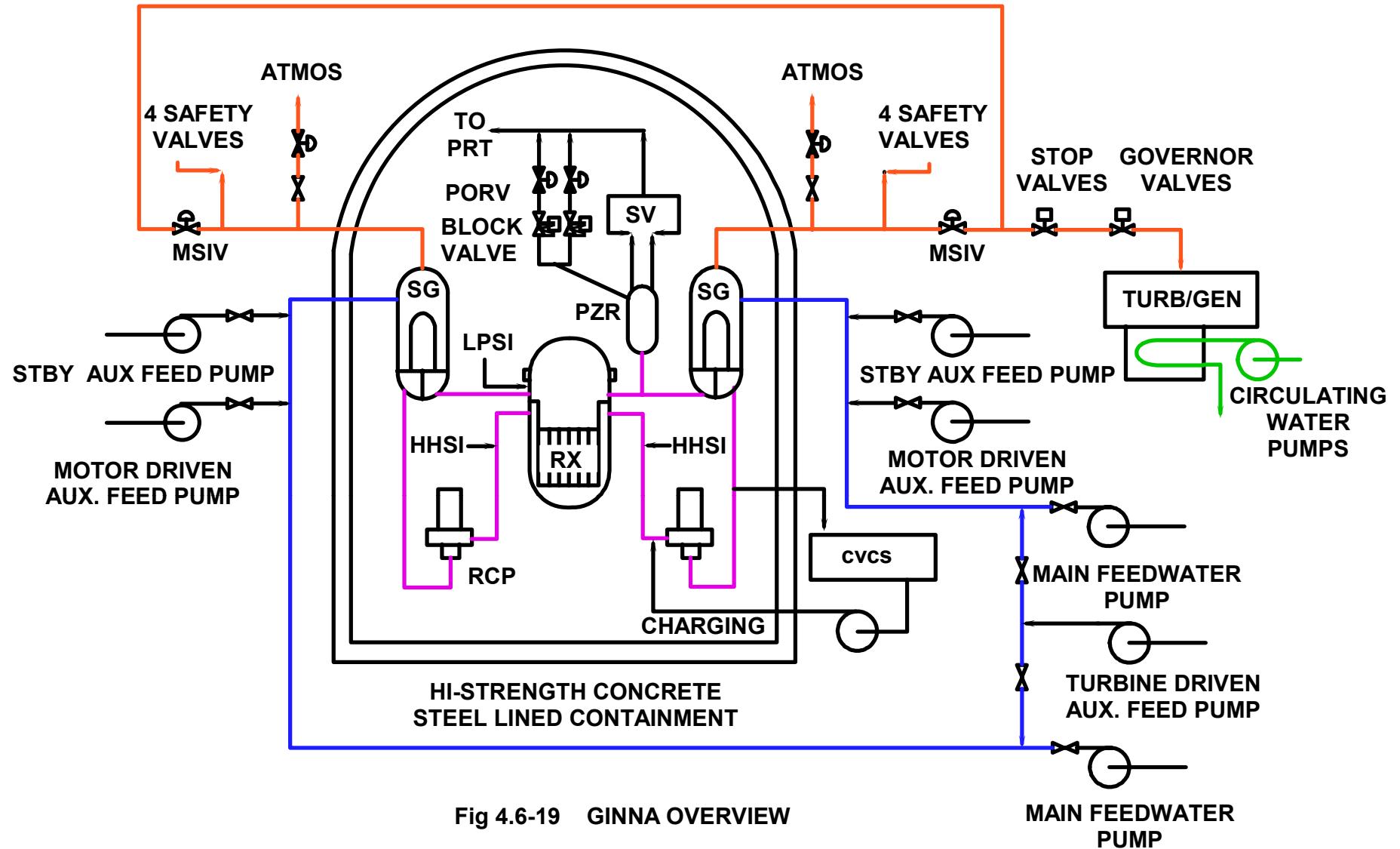


Fig 4.6-19 GINNA OVERVIEW

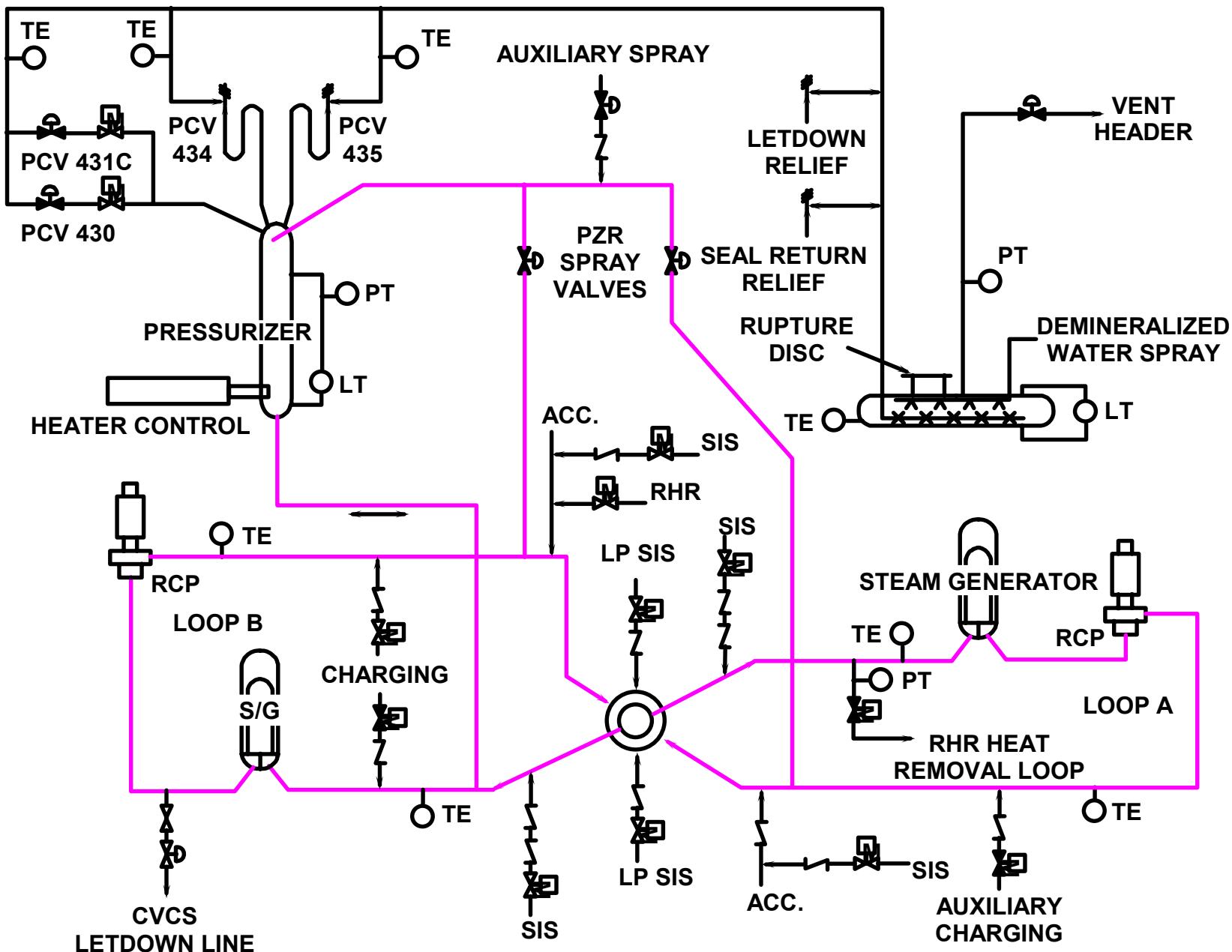


Figure 4.6-20 Ginna RCS Piping and Instrumentation

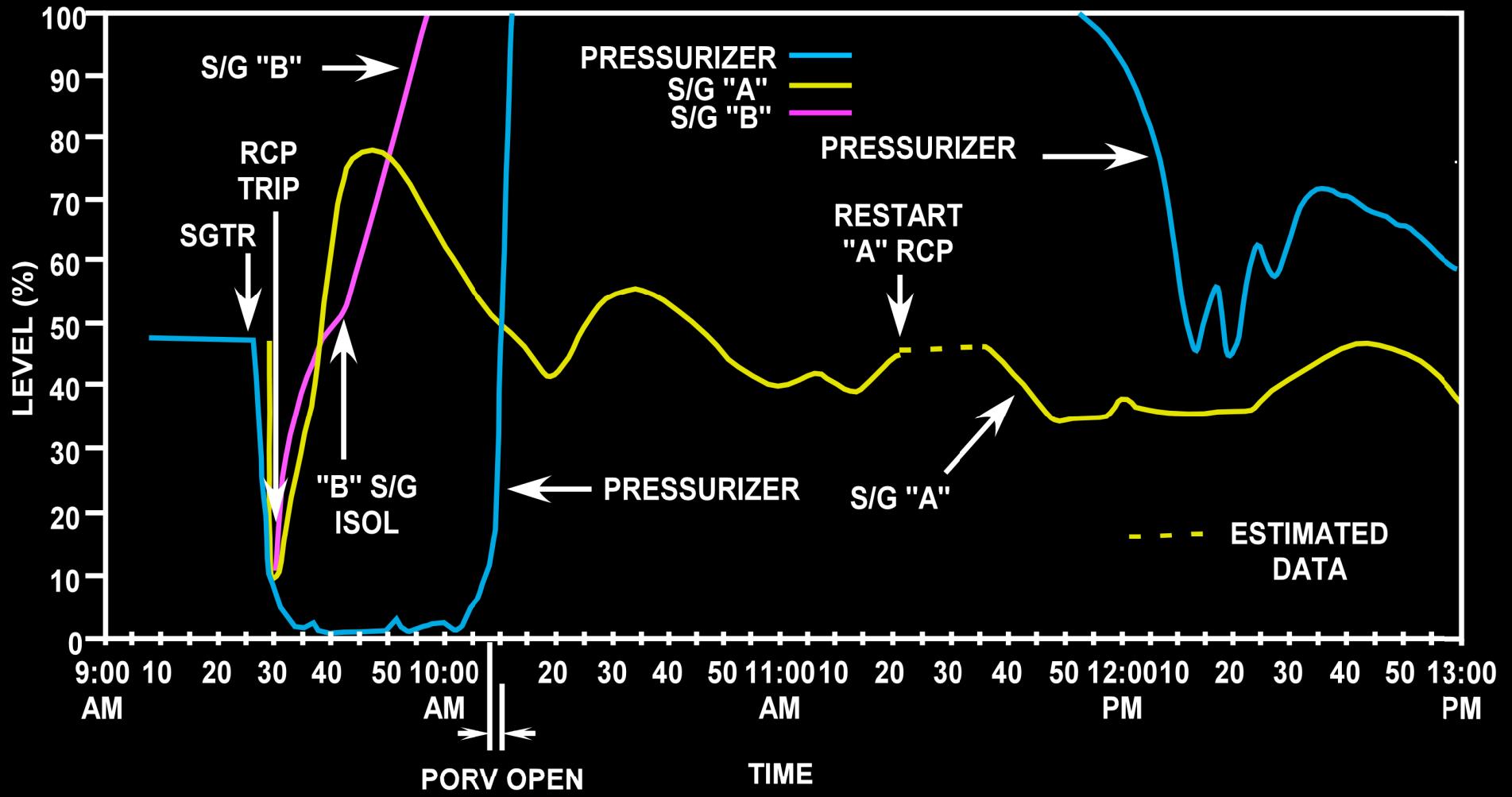


Figure 4.6-21 Ginna SGTR - Pressurizer and S/G Level Response

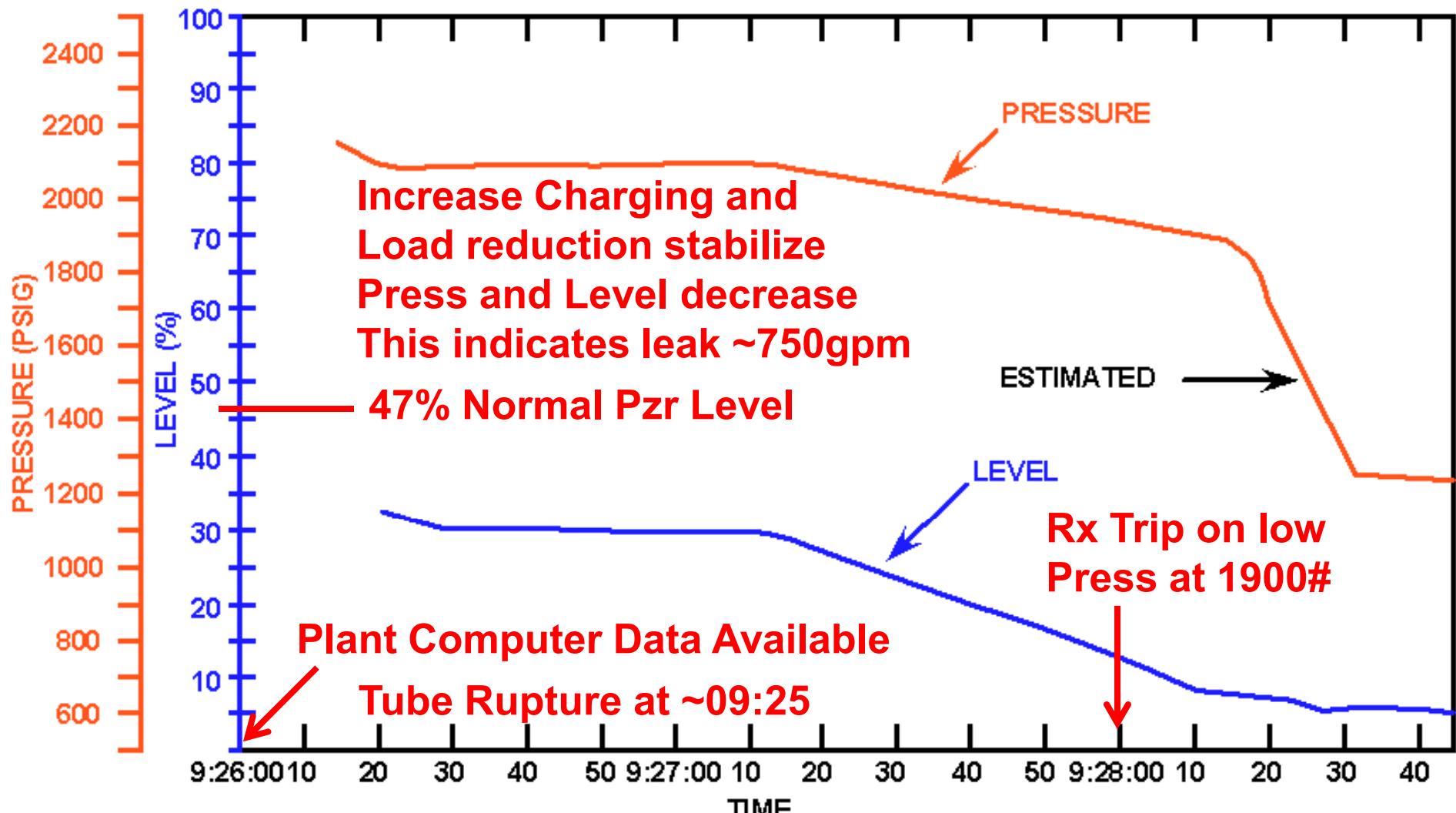


Figure 4.6-22 Ginna SGTR - Initial Pressurizer Pressure and Level Response
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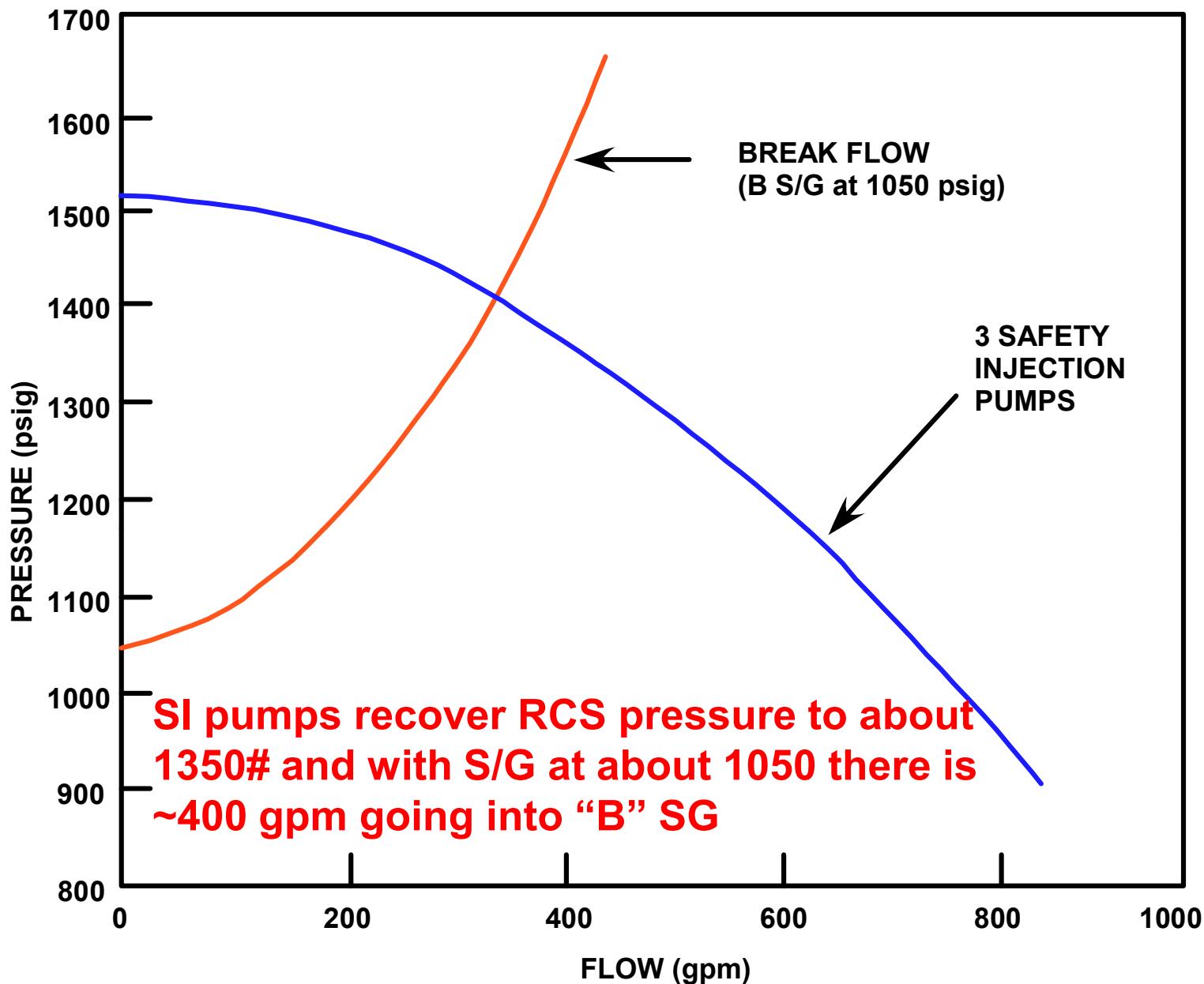
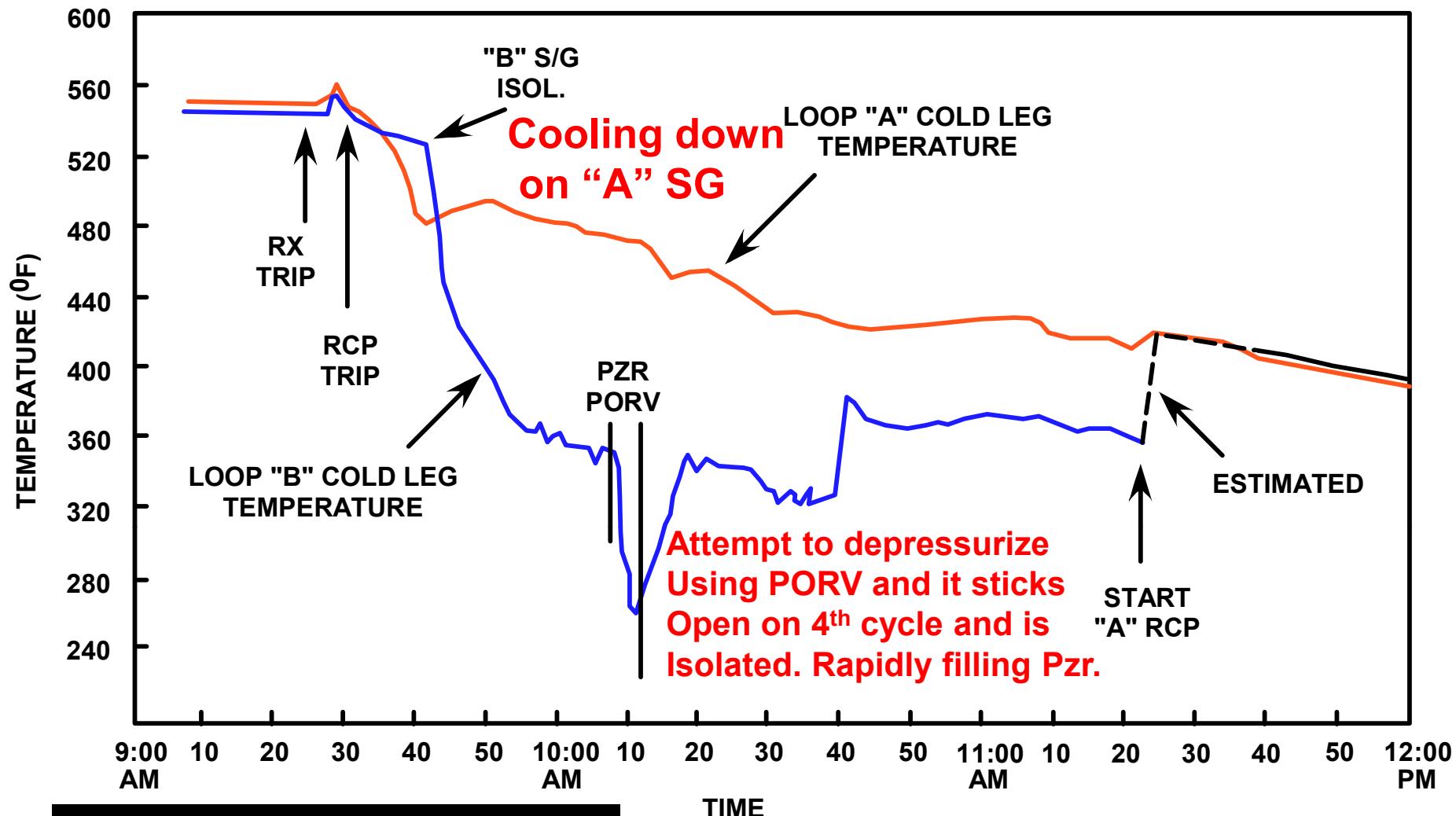
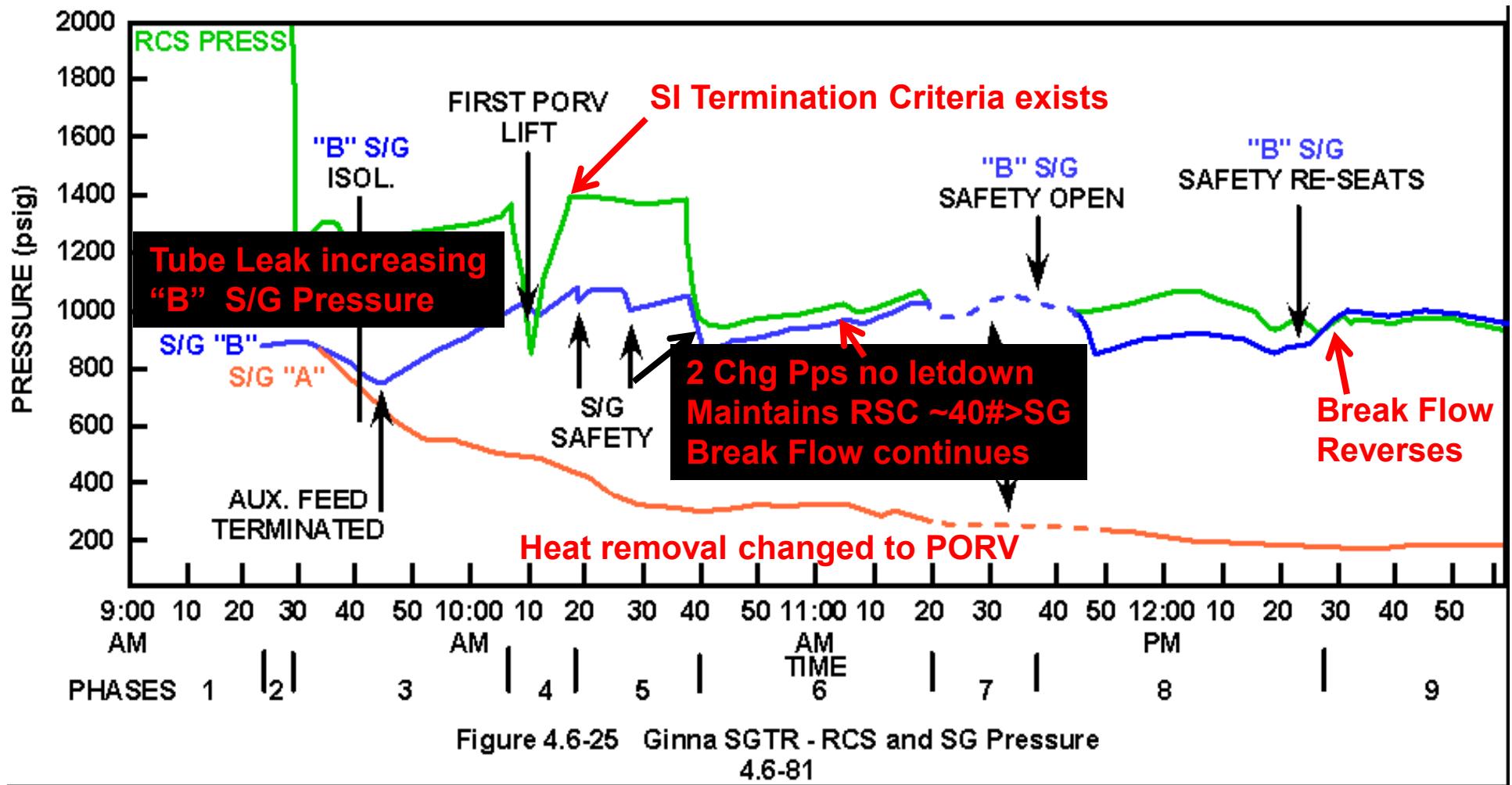


Figure 4.6-23 Ginna SGTR - SI and Break Flow
4.6-77



**At 9:40 "B" SG is isolated
B coolant loop stagnates.
B loop reverse flow out the
Ruptured tube**

Ginna SGTR - Cold-leg Temperature
4.6-79



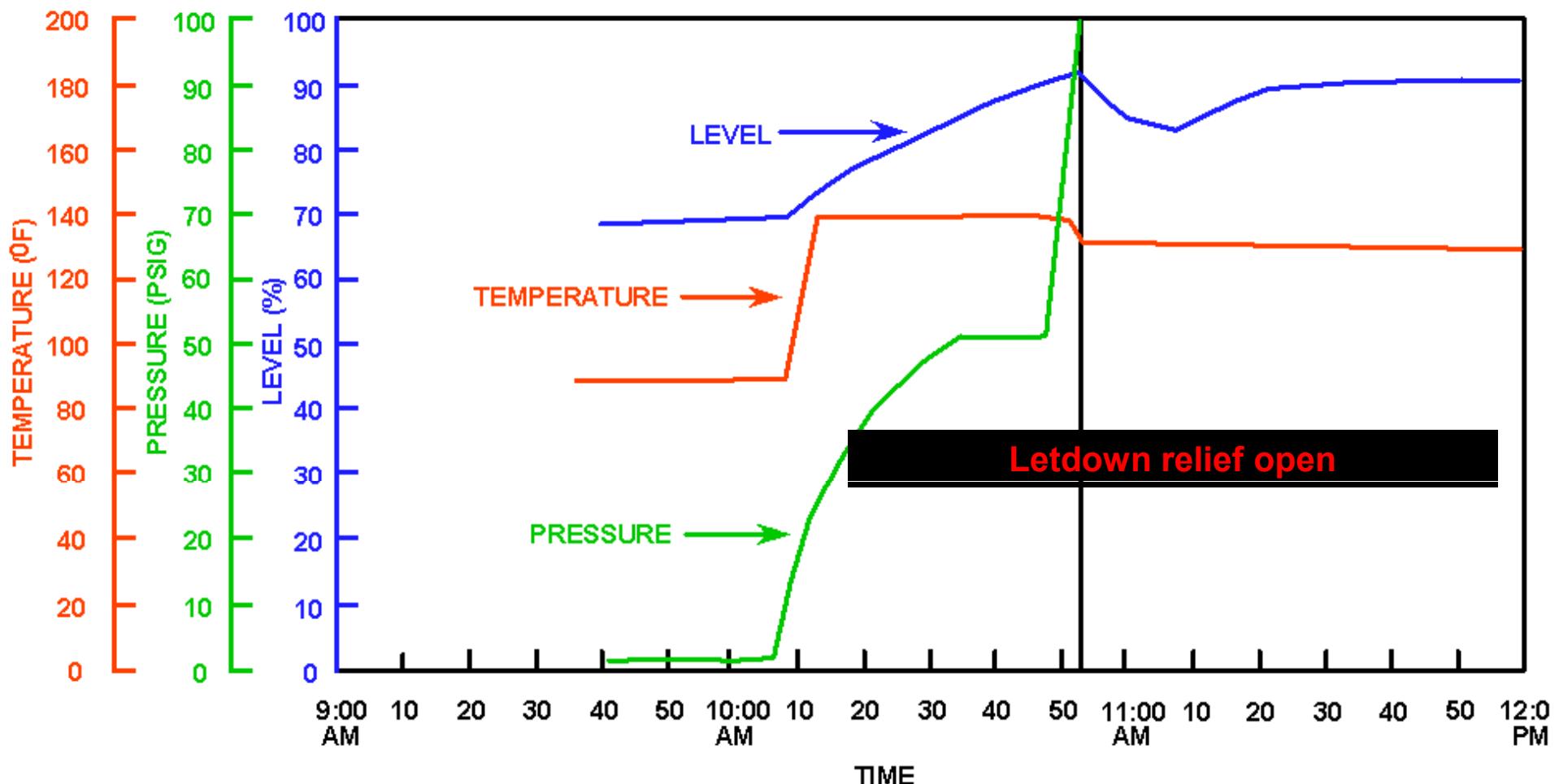


Figure 4.6-26 Ginna SGTR - PRT Parameters
4.6-83

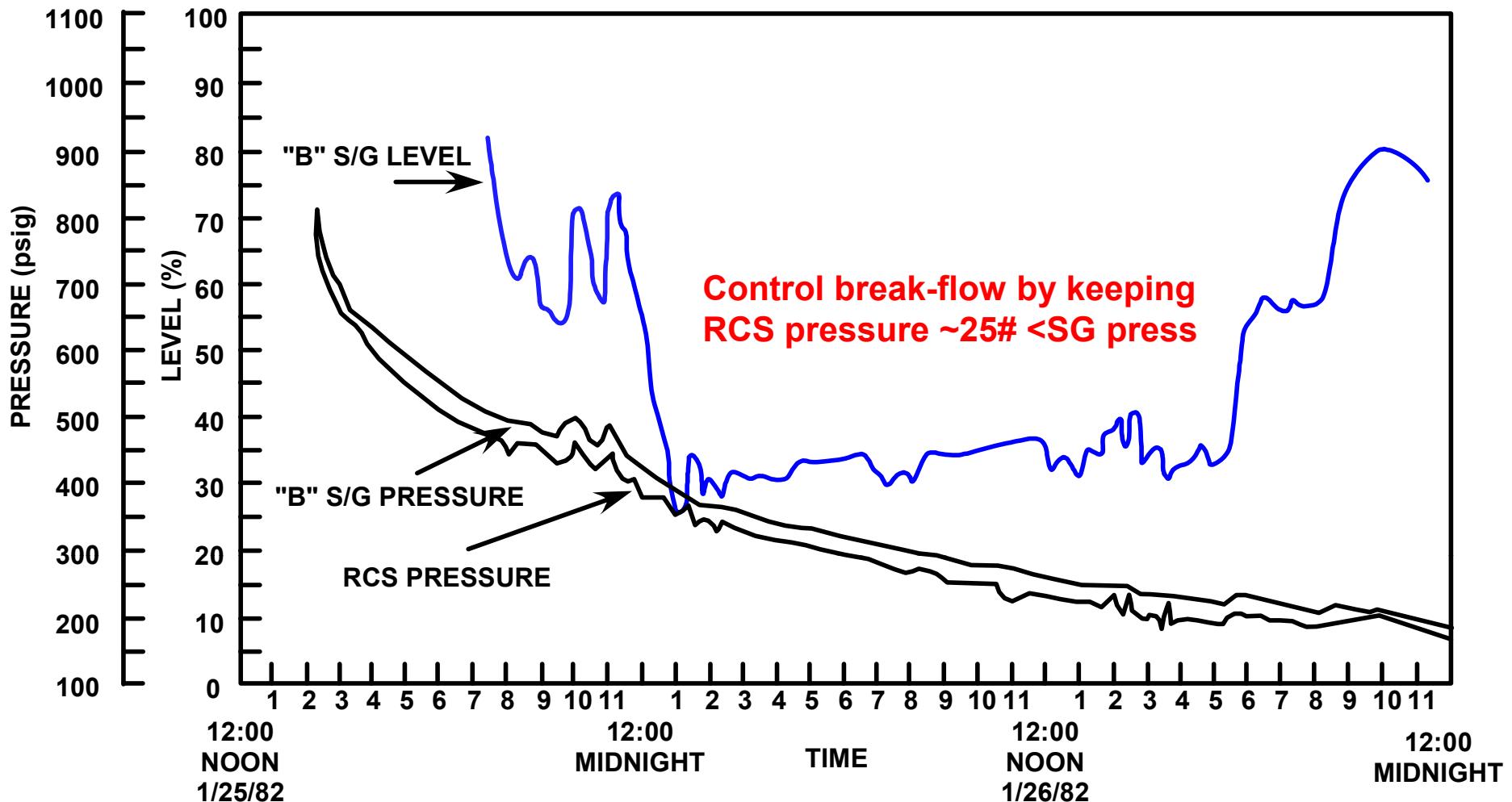


Figure 4.6-27 Ginna SGTR - Long-Term Cooldown and Depressurization
4.6-85

Ginna Lessons Learned

- Tripping RCPs slowed down and complicated recovery actions.
- PORV failure resulted in sec-to-pri leakage, RCS steam void formation, and Prz overfill.
- Opening of letdown iso valves resulted in overpressure of PRT.
- PRT rupture disc burst resulting in release of Reactor Coolant to Containment.
- Failure of SG Safety resulted in Rad releases & complicated recovery actions (lower SG pressure).

Objectives

Obj-1 Discuss why operator intervention is necessary to limit or prevent radiological releases during a **Steam Generator Tube Rupture (SGTR)** event.

Without operator action the affected SG and associated steam line will fill water solid. S/G PORVs and Safety valves are not designed to pass water and may fail open. The steam lines may fail due to the weight of water in the lines. These failures could result in a containment bypass event releasing radiation directly to the environment.

Obj-2 Discuss the primary-side and secondary-side indications of an SGTR in the control room.

- Primary
 - Decreasing pressurizer level
 - Decreasing RCS pressure
- Secondary
 - Condenser Offgas rad-monitor
 - SGBD rad-monitor
 - Main Steam rad-monitor
 - SG Steam flow / feed flow mismatch
 - SG water level deviation alarms

Obj-3 Discuss how the affected SG may be identified either prior to or following the reactor/turbine trip.

- Feedflow / Steam Flow mismatch
- Water level in affected SG returns on scale before other SGs
- Water level in affected SG higher than other S/Gs
- SGBD rad-monitor (if not common)
- Main Steam Line rad-monitor

Obj-4 List the initial actions taken by the operator once the affected SG has been identified.

- Isolate the affected SG.
 1. Isolate Feedwater & AFW.
 2. Close MSIV.
 3. Raise Setpoint on Affected SG ASDV
- These actions help minimize radiological releases & prevent SG overfill.
- Isolating the affected SG also allows use of the non-affected SG for cooling down RCS.

Obj-5 Discuss the actions required to stop the primary-secondary leakage.
Isolate the affected SG

- Cooldown RCS to saturation temp below affected SG pressure
- Depressurize RCS down to SG Pressure
- When pressurizer level is restored and SI termination criteria are meant stop SI pumps.
- Pressurizer level will slowly decrease as RCS depressurizes to SG Press and break flow stops

Obj-6 Discuss the problems associated with the following: Secondary-to-primary leakage, SG Overfill.

- Secondary to Primary Leakage
 - Dilution of primary (SD Margin)
- SG Overfill
 - Safety Valves and PORVs are not designed to pass water and may fail.
 - SG Lines fill with water to the MSIV and main steam line may fail.

Obj-7 List the principal systems & components affected by a loss of offsite power (LOOP).

- No RCPs – natural circulation cooldown required, slows recovery.
- No Steam Dumps to condenser – must use SG PORVs.
- Prz Sprays unavailable – must use Prz PORVs or Aux Spray (backup).

Obj-8 Discuss how plant cooldown and pressure control are accomplished with an SGTR and LOOP.

- Cooldown using SG PORV vs Stm Dumps
- Depressurize using PORV vs Normal or Aux Spray

OBJ-9 Discuss what affect the following events had on the SGTR transient at the Ginna Plant:

- Tripping of the reactor Coolant Pumps,
- Failure of pressurizer power-Operated relief valve,
- Automatic operation of letdown valves,
- Pressurizer relief tank failure, and
- Steam generator Safety Valve Failure.

The End